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THE DIFFICULTIES IN THE HEREDITY THEORY.

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THE CARTWRIGHT LECTURES FOR 1892, II.

(*Continued from Page 481, Vol. XXVI.*)

"Nur muss ich nochmals betonen, dass nach meiner Auffassung der Anfang einer neuen Reihe erblicher Abweichungen, also auch der Eintritt einer neuen Art ohne eine vorausgegangene erworbene Abweichung undenkbar ist."—VIRCHOW.

State of Opinion.—The above quotation from one of the most eminent authorities of our times represents the unshaken conviction of a very large class upon one side of the question of transmission of acquired characters, which is met by equally firm conviction upon the other side.

Herbert Spencer, whose entire system of biology, psychology, and ethics is based upon such transmission, says: "I will only add that, considering the width and depth of the effects which acceptance of one or other of these hypotheses must have on our views of Life, Mind, Morals, and Politics, the question Which of them is true? demands, beyond all other questions whatever, the attention of scientific men."[1] This shows that Spencer considers the matter still *sub judice*, and lest you may think I am bringing before you an issue in which learning and experience are ranged against ignorance and prejudice, I have taken some pains, by correspondence

[1]Nineteenth Century, 1889.

with a number of friends abroad, to learn the present state of opinion. The two leading English and French authorities upon this subject express themselves doubtfully.

Galton's mind is still wavering, as in his work of 1889:[1] "I am unprepared to say more than a few words on the obscure, unsettled and much discussed subject of the possibility of transmitting acquired faculties. . . . There is very little direct evidence of its influence in the course of a single generation, if the phrase of Acquired Faculties is used in perfect strictness and all inheritance is excluded that could be referred to some form of Natural Selection, or of Infection before birth, or of peculiarities of Nurture and Rearing."

Ribot, although in the center of the French Lamarckians, says: "Notwithstanding these facts the transmission of acquired modifications appears to be very limited, even when occurring in both of the parents."

Excepting from Kölliker; His, the Leipzig anatomist; Pflüger, the physiologist; Ziegler, in pathology; and De Vries, in botany, Weismann has not found much sympathy from his own countrymen in his opinion "that acquired characters cannot be transmitted; . . . that there are no proofs of such transmission, that its occurrence is theoretically improbable, and that we must attempt to explain the transformation of species without its aid."[2] Besides Virchow[3] and Eimer,[4] Haeckel has expressed himself strongly against Weismann. My colleague, Professor Wilson, writes me (Munich, December 31, 1891) that, while Weismann's modified theories as to the phenomena in the productive cells are pretty generally accepted, Hertwig, Hofer, Paully, Boveri, and others are pronounced advocates of the acquired-character-transmission theory.

In Paris, Brown-Séquard, who was among the first to test this problem experimentally by observing the inheritance of the effects of nerve-lesions; his assistant Dupuy, Giard, Duval,

[1]Natural Inheritance, 1889, p. 14.

[2]Biologisches Centralblatt, 1888, pp. 65 and 97.

[3]Ueber den Transformismus, Archiv. f. Anthropologie, 1889, p. 1.

[4]Organic Evolution, upon the Law of Inheritance of Acquired Characters. Tübingen, 1888. Trans.

Blanchard, and others are on the affirmative, or Lamarckian side.

Physiologists generally have fought shy of the question, although I think in the end they will be forced to take it up with the morphologists, and give us the physio-morphological theory of heredity of the future. Professor Michael Foster of Cambridge, and Professor Burdon-Sanderson, of Oxford, both write me that the question has hardly come into the physiological stage of inquiry at all. Yet in England Weismann has found his strongest supporters among some of the naturalists: Wallace, Lankester, Thiselton Dyer, Meldola, Poulton, Howes, and others; while, excepting Windle, the anatomists, including Mivart and Lawson Tait, with Sir William Turner as the most prominent, are all Lamarckians. Huxley, Romanes, and Flower are said to be doubtful. In this country the opinion of naturalists is directly the outgrowth of the class of studies in which each happens to be engaged. So far as I know every vertebrate and invertebrate palæontologist is a Lamarckian,[1] for in this field all evolution seems to follow the lines of inherited use and disuse; most of those engaged upon invertebrate zoology incline to follow Weismann. I have conversed upon this subject with many physicians, and find that without exception the transmission of acquired characters is an accepted fact among the profession.

Exact Statement of the Problem.—It is important at the outset to state most clearly what is and what is not involved in this discussion. Weismann[2] does not claim that the reproductive or germ-cells are uninfluenced by habit; on the other hand, he admits that most important modifications in these cells may and do result from changes of food, climate, from healthy or unhealthy conditions of the body; also from infectious disease, where it is quite as possible that the microbes may enter the reproductive cells as any other cells of the body; from alcoholism, where the normal molecular action of the protoplasm of the germ-cells may be disturbed,

[1]See the writings of Hyatt, Cope, Ryder, Dall, Scott, and others.

[2]See Essays upon Heredity and Kindred Biological Problems, 1889. Trans.

resulting in abnormal development, and there are some very interesting experiments which I shall cite on this point; from some nervous disorders which profoundly modify cell-function in all the tissues; in other words, *ovum sanum in corpore sano.* But to accept all this, and even to include all our rapidly increasing knowledge of the direct relation between such phenomena as production of deformities and determination of sex, and the influences of environment upon the ovum; or the influences of the mother upon the fœtus—this is all aside from the real question at issue.

It may be stated thus: Given *G*, the ova and spermatozoa, the germ-cells or material vehicles of hereditary characters; *S*, the body of somatic cells of all the other tissues conveying the hereditary characters of nerve, muscle, and bone; *V*, the variations in these body-cells "acquired" during lifetime; given these factors, the real question is: Do influences at work producing variations in certain body-cells of the parent so affect the germ-cells of the parent that they reappear in corresponding body-cells of the offspring? To take a concrete case, will the increased use of the cells of the extensor indicis muscle in the parent so stimulate that portion of the germ-cells which represents this muscle that the increment of growth will in any degree reappear in the offspring?

This is what is required of heredity upon the Lamarckian hypothesis, and I think you will see at once that while this hypothesis simplifies the problem of evolution it in a corresponding degree renders more difficult the problem of heredity —for we have not the first ray of knowledge of what such a process involves. There is no quality more essential to the scientific progress than common honesty; if we take a position let us face all its consequences; the more we reflect upon it, the more serious the Lamarckian position becomes.

In the present lecture let us first briefly review the progress of the science of heredity which has led up to the present discussion. Second, Let us examine the evidence for and against the Lamarckian theory, and inquire how far natural selection can explain all the facts of evolution. Third, Let us examine the evidence for such a continuous relation between

the body-cells and the germ-cells, as must exist if the Lamarckian theory is the true one.

History of the Heredity Theory.—In a valuable summary of the past theories of heredity[1] J. A. Thomson distinguishes three general problems, which are often confused. 1st. What characters distinguish the germ-cells from other cells of the body? 2d. How do the germ-cells derive these distinguishing characters? 3d. How shall we interpret "particulate" inheritance, or the reappearance of single peculiarities in the offspring?

The various theories may be grouped under two heads, "Pangenesis of Germ-cells" and "Continuity of Germ-cells," according to the dominating idea in each.

1. *Pangenesis.*—The idea prevading pangenesis was first expressed by Democritus that the "seed" of animals was derived by contributions of material particles from all parts of the bodies of both sexes, and that like parts produced like. Two thousand years later, Buffon revived this conception of heredity in his "molecules organiques." In 1864 Herbert Spencer suggested the existence of "physiological units," derived from the body-cells of the parent, forming the germ-cells and then developing into the body-cells of the offspring.

It is interesting to note the course of Darwin's thought upon this matter in his published works and in his "Life and Letters." He was at first strongly opposed to the views upon evolution advanced by Buffon, by Erasmus Darwin, his grandfather, expanded by Lamarck, and now known as Lamarckian. But gradually becoming convinced that his own theory of natural selection could not account for all the facts of evolution, he unconsciously became a strong advocate of Lamarck's theory, and contributed to it a feature which Lamarck had entirely omitted, namely, a theory of heredity expressly designed to explain the transmission of acquired characters. Darwin's[2] "provisional hypothesis of pangenesis" postulated a material connection between the body-cells and

[1]See Proc. Roy. Soc. Edin., 1888, p. 93.

[2]See Animals and Plants under Domestication, 1875, vol. ii., p. 349.

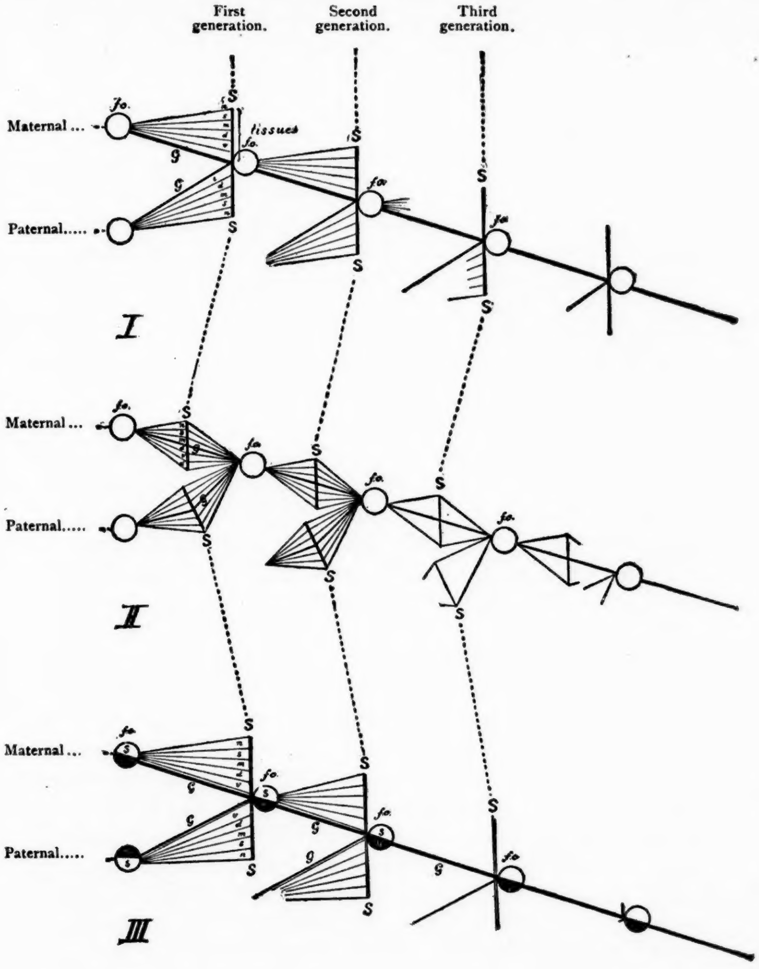
the germ-cells by the circulation of minute buds from each cell; each body-cell throws off a "gemmule" containing its characteristics; these gemmules multiply and become especially concentrated in the germ-cells; in the latter they unite with others like themselves; in course of development they grow into cells like those from which they were originally given off. (See Diagram II.)

Galton,[1] who has always been doubtful in regard to use-inheritance, while advancing a theory of "continuity," partly approved Darwin's pangenesis idea in the cautious statement: "Each cell may throw off a few germs that find their way into the circulation and thereby have a chance of entering the germ-cells." At the same time Galton contributed very important experimental disproof of the existence of "gemmules," and, in fact, of the popular idea, of the circulation of hereditary characters in the blood, by a series of careful experiments upon the transfusion of blood in rabbits; he found that the blood did not convey with it even the slightest tendency to transfer normal characteristics from one variety to another.

Professor Brooks,[2] of the Johns Hopkins University, then contributed an original modification of pangenesis in which the functions of the ova and spermatozoa were sharply differentiated. (1) He regarded the ovum as a cell especially designed as a storehouse of hereditary characteristics, each characteristic being represented by material particles of some kind; thus hereditary characters were handed down by simple cell division, each fertilized ovum giving rise to the body-cells in which its hereditary characters were manifested and to new ova in which these characters were conserved for the next generation (this portion of Brooks's theory is very similar to Galton's and Weismann's). 2. The body-cells have the power of throwing off "gemmules," but this is exercised mainly or exclusively when its normal functions are disturbed, as in metatrophic exercise or under change of environment. 3. These gemmules may enter the ovum, but the spermatozoan is their main center. According to this view the female

[1]Contemporary Review, vol. xxvii., p. 80–95.

[2]The Law of Heredity, 1883.



f. o., fertilized ovum or *embryo*, containing maternal and paternal characteristics; *S*, soma, or adult body, containing *n, s, m, d, v*, *somatic cells* of the various tissues; and *G*, *germ-cells* of the reproductive glands.

I. Histogenesis.—Showing the successive rise *G*, and union *f. o.* of the maternal and paternal germ-cells by direct histogenesis.

II. Pangenesis.—Showing the tissues of the body *S*, contributing to the germ-cells *G*, so that each *f. o.* is composed of elements from both the somatic and germ-cells.

III. Continuity.—Showing the division of the embryo, *f. o.*, into somatoplasm, *s* (from which arise the body-cells), and germ-plasm, *G* (which passes direct to the germ-cells), establishing a direct continuity.

cell is rather conservative and the male cell progressive; the union of these cells produces variability in the offspring, exhibited especially in the regions of the offspring corresponding to the regions of functional disturbance in the parent. This hypothesis was well considered, and while that feature of it which distinguishes the male and female germ-cells as different in kind has been disproved, and the whole conception of gemmules is now abandoned, the fact still remains that we shall nevertheless be obliged to offer some hypothesis to explain the facts disregarded by Weismann for which Brooks provides in his theory of the causes of variation.

2. *Continuity of Germ-cells.*—The central idea here is an outgrowth of our more modern knowledge of embryogenesis and histogenesis, and is, therefore, comparatively recent; it is that of a fundamental distinction between the "germ-cells," as continuous and belonging to the race, and the "body-cells," as belonging to the individual. Weismann has refined and elaborated this idea, but it was not original with him.

Richard Owen,[1] in 1849, Haeckel,[2] in 1866, Rauber,[3] in 1879, in turn dwelt upon the distinction which Dr. Jaeger, now of manufacturing fame, first clearly stated:

"Through a great series of generations the germinal protoplasm retains its specific properties, dividing in every reproduction into an ontogenetic portion, out of which the individual is built up, and a phylogenetic portion, which is reserved to form the reproductive material of the mature offspring. This reservation of the phylogenetic material I described as the continuity of the germ protoplasm. . . . Encapsuled in the ontogenetic material the phylogenetic protoplasm is sheltered from external influences, and retains its specific and embryonic characters." The latter idea has, under Weismann, been expanded into the theory of isolation of the germ-cells.

Galton introduced the term "stirp" to express the sum total of hereditary organic units contained in the fertilized ovum. His conception of heredity was derived from the

[1]See Parthenogenesis, in his Anatomy of Vertebrates.

[2]Generelle Morphologie, vol. ii., p. 170.

[3]Zool. Anz., vol. ix., p. 166.

study of man, and he supported the idea of continuity in the germ-cells in order to account for the law of transmission of "latent" characters; it is evident from this law that only a part of the organic units of the "stirp" become "patent" in the individual body; some are retained latent in the germ-cells, and become patent only in the next or some succeeding generation. For example, the genius for natural science was "patent" in Erasmus Darwin, grandfather of the great naturalist, it was "latent" in his son, and reappeared intensified in his grandson, Charles Darwin. I have elsewhere[1] summed up as follows Galton's general results, which so remarkably strengthen the "continuity" idea: We are made up, bit by bit, of inherited structures, like a new building, composed of fragments of an old one, one element from this progenitor, another from that, although such elements are usually transmitted in groups. The hereditary congenital constitution thus made up is far stronger than the influences of environment and habit upon it. A large portion of our heritage is unused, for we transmit peculiarities we ourselves do not exhibit. The contributions from each ancestor can be estimated in numerical proportions, which have been exactly determined, from statistics of stature in the English race; thus the contributions from the "patent" stature of the two parents together constitute one-half; while the contributions by "latent" heritage from the grandparents constitute one-sixteenth, etc. One of the most important demonstrations by Galton, is the *law of regression;* this is the factor of stability in race type which acts as gravitation does upon the pendulum; if an individual or a family swing far from the average characteristics of their race, and display exceptional physical or mental qualities, the principle of regression in heredity tends to draw their offspring back to the average.

Now how shall we distinguish regression from reversion? Very clearly, I think; *regression* is the short pull which tends to draw every variation and the individual as a whole back to the contemporary typical form, while *reversion* is the long pull which draws the typical form of one generation back to

[1]Atlantic Monthly, March, 1891, p. 359.

the typical form of a very much earlier generation. These forces are evidently akin, and in the shades of transition from one type to another we would undoubtly find a constant diminution numerically in the recurrence of characters of the older type, and thus "regression" would pass insensibly into "reversion."

Weismann has carried the idea of continuity to its extreme in his simple and beautiful theory of heredity, which is founded upon the postulate that there is a distinct form of protoplasm, with definite chemical and molecular properties, set apart as the vehicle of inheritance; this is the *germ-plasm*, *G*, quite separate from the protoplasm of the body-cells or *somatoplasm*, *S*. Congenital characters arising in the germ-cells are called *blastogenetic*, while acquired characters arising in the body-cells are *somatogenetic*.

To clearly understand this view, let us follow the history of the fertilized ovum in the formation of the embryo. It first divides into somatoplasm and germ-plasm (see Diagram III.), the former supplies all the tissues of the body—*n*, *s*, *m*, *d*, *v*, nervous, muscular, vascular, digestive, etc.—with their quota of hereditary structure; the residual germ-plasm is kept distinct throughout the early process of embryonic cell division until it enters into the formation of the nuclei of the reproductive cells, the ova or spermatozoa. Here it is isolated from changes of function in the somatoplasm, and in common with all other protoplasm is capable of unlimited growth by cell division without loss or deterioration of its past store of hereditary properties; these properties are lodged in the nucleus of each ovum and spermatozoan, and these two cells, although widely different in external accessory structure (because they have to play an active and passive part in the act of conjugation), are exactly the same in their essential molecular structure, and the ancestral characters they convey differ only because they come along two different lines of descent. When these cells unite they carry the germ-plasm into the body of another individual. Thus the somatoplasm of each individual dies, while the germ-plasm is immortal; it simply shifts its abode from one generation to another; it constitutes the

chain from which the individuals are mere offshoots. Thus the germ-plasm of man is continuous with that of all ancestors, in his line of descent, and we have an explanation of the early stages observed in development in which the human embryo passes through a succession of metamorphoses resembling the adult forms of lower types.

In order to emphasize, as it were, the passage of the germ-plasm from one generation to another without deterioration in its marvellous hereditary powers, Weismann added the idea of its *isolation.* Not only does he repudiate the pangenesis notion of increment of germ-plasm by addition of gemmules, but he believes that it is unaffected by any of the normal changes in the somatic or body-cells. As this continuity and isolation would render impossible the transmission of characters acquired by the somatoplasm, Weismann began to examine the evidence for such transmission, and coming to the conclusion that it was insufficient, in his notable essay on "Heredity," in 1883, he boldly attacked the whole Lamarckian theory and has continued to do so in all his subsequent essays.

Being forced to explain evolution without this factor, he claimed that variation in the germ-plasm was constantly arising by the union of plasmata from different lines of descent in fertilization, and that these variations are constantly being acted upon by Natural Selection to produce new types. He thus revived Darwin's earlier views of evolution, and this in part explains his strong support by English naturalists.

It will be seen at once that there are a number of distinct questions involved.

The matter of first importance in life is *the repetition and preservation of type,* the principle which insures the unerring accuracy and precision with which complex organs are built up from the germ-cells; the force of regression and the more remote forces of reversion all work in this conservative direction; the theory of the preservation of these forces in a specific and continous form of protoplasm is by far the most plausible we can offer at present. The matter of second importance, but equally vital to the preservation of races, in the long run, is *the formation of new types* adapted to new circumstances of

life. I shall now attempt to show that the facts of evolution, while not inconsistent with the idea of continuity of the germ-plasm, are wholly at variance with the idea of its independence, separation, or isolation from the functions of the body. This can be done by proving, first, that the theory of evolution solely by natural selection of chance favorable variations in the germ-plasm is inadequate; second, that the inheritance of definite changes in the somatic cells is also necessary to evolution, and therefore there must exist some form of force or matter which connects the activities of the somatoplasm with those of the germ-plasm.

In the following table are placed some of the facts of human evolution which we have observed in the first lecture, and as they are part of inheritance, they also constitute the main external phenomena of heredity:

Phenomena of Heredity.

Conservative (toward past type).	*Neutral.*	*Progressive* (toward future type).
a. Repetition of parental type.	Fortuitous	*a.* Definite Variation in single characters, by accumulation=.
	and	
b. Regression (in many characters) to contemporary race type.	Indefinite	*b.* Definite Variation in many characters (from contemporary race type).
c. Reversion (mainly in single characters) to past race type.	Variations.	

What are the causes of these various phenomena?

Factors of Evolution.—The term "kinetogenesis" has been applied to the modern form of the Lamarckian theory, for it is an application of kinetic or mechanical principles to the origin of all structures such as teeth, bone, and muscle. It would be fatal to this theory, if it could be shown that the

changes taking place in course of a normal individual life, under the laws of use and disuse, are inadaptive, or do not correspond to those observed in the evolution of the race.

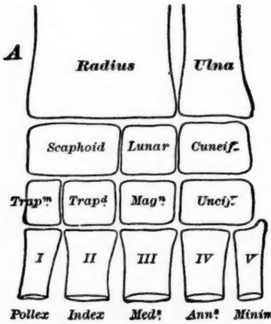
The Relative Growth of Organs.—Ball,[1] in his long argument against Lamarckianism, claims that such is the case, and that use-inheritance would be an actual evil: "Bones would often be modified disastrously. Thus the condyle of the human jaw would become larger than the body of the jaw, because as the fulcrum of the lever it receives more pressure. Some organs (like the heart, which is always at work) would become inconveniently or unnecessarily large. Other absolutely indispensible organs which are comparatively passive or are very seldom used would dwindle until their weakness caused the ruin of the individual or the extinction of the species." He later cites from Darwin[2] the "Report of the United States Commission upon the Soldiers and Sailors of the Late War," that the longer legs and shorter arms of the sailors are the reverse of what should result from the decreased use of the legs in walking and increased use of the arms in pulling. A little reflection on Mr. Ball's part would have spared us this crude exception, for whatever difficulties may arise from theoretical speculation as to the laws of growth, or from statistics, the fact remains that activity must increase adaptation in every part of the organism; otherwise the runner and the trotting horse should be kept off the track to increase their speed, the pianist should employ as little finger-exercise as possible. If the growth tendencies in single organs are transmitted, it is evident that the adaptive adjustments between these tendencies will also be transmitted.

The Feet.—In point of mechanical adaptation, man, with the single exception of his thumb and forearm, has not progressed beyond the most primitive eocene quadruped. The laws of evolution of the foot in the ungulate or hoofed animals, which have been especially studied by Kowalevsky, Ryder, Cope, and myself, afford a conclusive demonstration that the skeletal changes in the individual coincide with those which

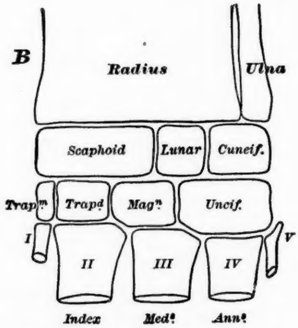
[1]Op. cit., p. 129.

[2]Descent of Man, p. 32.

will mark the evolution of the race. In the earliest ungulates the carpals and tarsals are disposed, as in man, directly above each other, with serial joints, as in *A;* in the course of evolution all these joints became interlocking, as in *B*, thus producing an alternation of joints and surfaces similar to those which give strength to masonry. In studying these facts Cope[1] reached a certain theory as to the motion of the foot and leg in locomotion. In trying to apply this, I found it could not be harmonized with all the facts, and I worked out an entirely different theory.[2] This I found subsequently coincided exactly with the results previously obtained by Muybridge, by the aid of instantaneous photographs, and summarized by Professor Harrison Allen, of the University of Pennsylvania.[3]



Primitive Ungulate Foot.—Lines of vertical cleavage on either side of the middle toe, III. Spreading of toes would cause separation of the carpals.



Recent Ungulate Foot.—No lines of verticle cleavage. All joints broken by enlargement of scaphoid, unciform, and radius, the bones receiving greatest impact in walking. Lateral toes, I., V., degenerate.

The monodactylism of the horse was attained by the atrophy of the lateral toes, and concentration of the major axis of body-weight and strain upon the middle finger and toe. Man is also tending toward monodactylism in the foot

[1]American Naturalist, 1887, p. 986.

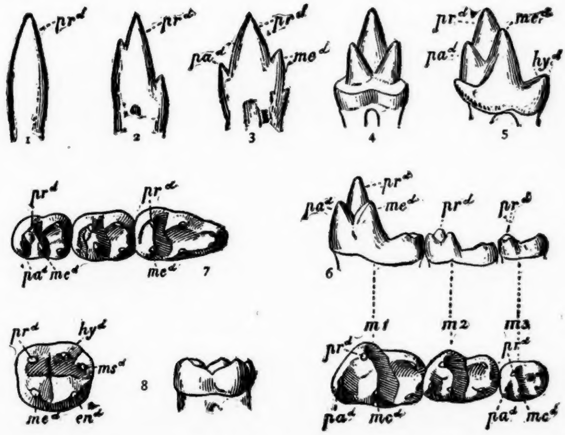
[2]See Trans. of American Philosophical Society, p. 561. Philadelphia, 1889.

[3]The Muybridge Work at the University of Pennsylvania. Philadelphia, 1388.

by the establishment of the major axis through the large toe and atrophy of the outer toes. The present atrophy of our small toe is as good a parallel as we can find of the changes which were occurring in the eocene period among the ancestors of the horse.

The Teeth.—But how about the teeth, in which there is an absolute loss of tissue in consequence of use? This is another objection raised by Ball, Poulton, and others which disappears upon examination.

The dental tissues, while the hardest in the body, and, unlike bone, incapable of self-repair, are not only both living and sensitive, but, to a very limited degree, plastic and capa-

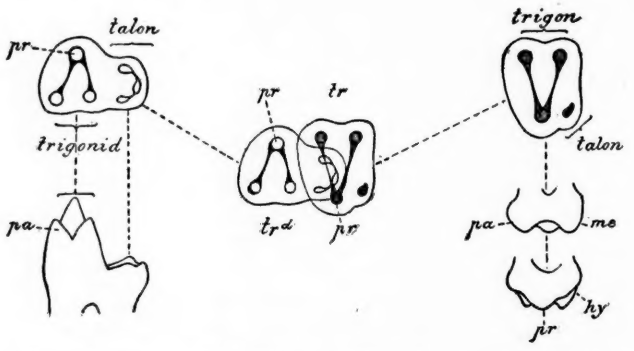


EVOLUTION OF THE CUSPS OF THE HUMAN LOWER MOLAR.—*prd*, protoconid (anterior buccal cusp); *pad*, paraconid; *med*, metaconid (anterior lingual cusp); *hyd*, hypoconid (posterior buccal); *end*, entoconid (posterior lingual cusp); *msd*, mesoconulid (intermediate cusp). Fig. 1.—Reptilian stage. Fig. 2-5.—Mesozoic mammals, first lower molars showing rise of ancestral cusps. Fig. 6.—Eocene carnivore (*Miacis*), showing how the low tubercular crown *m3* is derived from the high crown *m1*. Fig. 7.—Eocene monkey (*Anaptomorphus*), showing how the primitive anterior lingual cusp, *pad*, disappears. Fig. 8.—Human first molar with its ancestral cusps.

ble of change of form. *Ex hypothesi*, it is not the growth, but the reaction tendency which produces the growth, which is transmitted. The evolution of the teeth, therefore, falls into the same category as bone.[1] In the accompanying figures I

[1]See especially the papers of Ryder, Cope, and the writer, "Evolution of Mammalian Molars to and from the Tritubercular Type," American Naturalist, 1889.

have epitomized the slow transformation of the single-fanged conical reptilian tooth, such as we see in the serpents, into the low-crowned human grinder. We now know all the transition forms, so that we can homologize each of the cusps of the human molar with its varied ancestral forms in the line of descent. For example, the anterior lingual or inner cusp of the upper true molars traces its pedigree back to the reptilian cone. The anterior triangle of cusps, or trigon, seen in the mosozoic mammalia, and persisting in the first inferior true molar of the modern dog, is still seen in the main portion of the crown of the human upper molars (*pr, pa, me*). To this was added, ages ago, the posterior lingual cusp, or hypocone, which, as Cope has shown, is exhibited in various degrees of development in different races and is an important race



Lower molar. Upper and lower molars opposed. Upper molar.

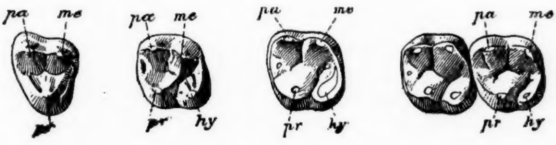
KEY TO PLAN OF UPPER AND LOWER MOLARS IN ALL MAMMALS.—Each tooth consists of a triangle, *trigon*, with the protocone, *pr*, at the apex. The apex is on the inner side of the upper molars and on the outer side of the lower molars.

index.[1] A glance through the diagrams shows that the development of the crown has been by the successive addition of new cusps. Without entering upon the details of evidence which would be out of place here, I may say briefly that the new main cusps have developed at the points of maximum

[1]The upper molars in many Esquimaux are triangular (as in Fig. 11); in most negroes they are square (Fig. 12). In our race they are intermediate.

wear (*i. e.*, use), and conversely in the degeneration of the crown, disuse foreshadows atrophy and disappearance.

Upon the whole, with some exceptions which we do not at present understand, the course of evolution of the teeth supports the evidence derived from the skeleton, that, whether any true causal relation has existed or not, the lines of individual transformation in the whole fossil series preceded those of race transformation.



EVOLUTION OF THE HUMAN UPPER MOLARS.—Fig. 9.—*Anaptomorphus*, a lower eocene monkey. Fig. 10.—An upper eocene monkey. Fig. 11 and 12.—Human, 11, Esquimaux; 12, negro. See addition of "talon," *hy*, to "trigon" composed of *pa, pr, me.*

The Rise of New Organs.—We owe to Dr. Arbuthnot Lane a most interesting series of studies upon the influences of various occupations upon the human body. He proves conclusively that individual adaptation not only produces profound modifications in the proportions of the various parts, but gives rise to entirely new structures.

His anatomy and physiology of a shoemaker[1] shows that the lifelong habits of this laborious trade produce a distinct type, which if examined by any zoological standard would be unhesitatingly pronounced a new species—*homo sartorius.* The psychological analysis which a Dickens or Balzac would draw, showing the influences of the struggle for existence upon the spirit of this little tailor could not be more pathetic than Dr. Lane's analysis of his body. The bent form, the crossed legs, thumb and forefinger action, and peculiar jerk of the head while drawing the thread, are the main features of sartorial habit. The following are only a few of the results: The muscles tended to recede into tendons and the bony surfaces into which they were inserted tended to grow in the

[1]Journal of Anatomy and Physiology, 1888, p. 595.

direction of the traction which the muscle exerted upon them. The articulation between the sternum and the clavicle was converted into a very complex arthrodial joint, constituting almost a ginglymoid articulation. The sixth pair of ribs were anchylosed to the bodies of the vertebræ, indicating that they had ceased to rise and fall with sternal breathing, and that respiration was almost exclusively diaphragmatic. The region of the head and first two vertebræ of the neck was still more striking: the transverse process of the right side of the atlas, toward which the head was bent, formed a new articulation with the under-surface of the jugular process of the occipital bone, "a small synovial cavity surrounded this acquired articulation, but there was no appearance of a capsular ligament;" the left half of the axis was united by bone to the corresponding portion of the third cervical; there was found a new upward prolongation of the odontoid peg of the axis, and a new accessory transverse ligament to keep it from pressing upon the cord. In short, "the anatomy of the shoemaker represents the fixation and subsequent exaggeration of the position and tendencies to change which were present in his body when he assumed the position for a short period of time.

Rate of Inheritance.—This illustration serves also to emphasize the great contrast between the rapidity of individual transformation and the slowness of race transformation. No one would expect the son of this shoemaker to exhibit any of these acquired malformations. Yet Dr. Lane thinks he has observed such effects in the third generation by the summation of similar influences.

All palæontological evidence goes to show that the effects of normal habits, if transmitted at all, would be entirely imperceptible in one generation. The horse, for example, has not yet completely lost the lateral toes which became useless at the end of the upper eocene period. This objection as to rate of evolution may be urged with equal force against the natural-selection theory. It is obvious that the active progressive principle in evolution, whatever it is, must contend with the enormous conservative power of inheritance, and

this, to my mind, is one of the strongest arguments against the possibilities of the rise of adaptive organs by the selection of chance favorable variations in the germ-plasm.

Application to Human Evolution.—Principles underlying these illustrations may now be applied to some of the facts in human evolution brought out in the first lecture. They show that if functional tendencies are transmitted we can comprehend the distinct evolution history of each organ; the rise and fall of two organs side by side; the definite and purposive character of some anomalies; the increase of variability in the regions of most rapid evolution; the correlation of development, balance and degeneration in the separate organs of the shoulder, hand and foot.

Yet even granting this theory, there still remain difficulties. The relation of use and disuse to some of the contemporary changes in the human backbone is rather obscure. I would hesitate to pronounce an opinion as to whether our present habits of life are tending to shorten the lumbars, increase the spinal curvatures, and shift the pelvis, without making an exhaustive study of human motion. Among the influences which Dr. Lane has suggested[1] as operative here are the wearing of heeled shoes and the increase of the cranium. He considers the additional or 6th lumbar vertebra as a new element rather than as a reversion, and works out in some detail the mechanical effects of the presence of the fœtus upon female respiration (*i.e.*, in the sternal region) and upon the pelvis. Now, if it be true that the female pelvis is relatively larger in the higher races than in the lower, I do not think that Dr. Lane can sustain his point, because in the lower races the fœtus is carried for an equally long period, during a much more active life, and in a more continuously erect position. Therefore, if these mechanical principles were operating, the pelvis in the modern lower races should be larger than in the higher. On the other hand, the form of the female pelvis in the higher races is one of the best established selecting or eliminating factors, a large pelvis favoring frequent births

[1]Journal of Anatomy and Physiology, 1888, p. 219.

and the preservation of those family stirps in which it occurs. I mention this to show how cautious we must be in jumping to conclusions as to kinetogenesis.

The transformism in all the external features of the skull, jaws, and teeth may be attributed to inherited tendencies toward hypertrophy or atrophy; but how about the convolutions of the turbinal bones or the complex development of the semicircular canals and cochlea of the internal ear and the many centers of evolution which are beyond the influences of use and disuse? These are examples of structures which fortify Weismann's contention, for if complex organs of this character can only be accounted for by natural selection, why consider selection inadequate to account for all the changes in the body?

Difficulties in the Natural-Selection Theory.—The answer, I think, is readily given: We do not know whether use and disuse are operating upon the mechanical construction of the ear; we do know that the organ can be rendered far more acute by exercise; but even if it were true that habit can exert no formative influence, the ear is one of those structures which since its first origin has been an important factor in survival, and *may* therefore have been evolved by natural selection. Now the very fact that selection may have to care for variations in such prime factors in survival as the ear, renders it the more difficult to conceive that it also is nursing the minutiæ of variation in remote, obscure, and uncorrelated organs.

Even in the brief review of human evolution in the first lecture I have pointed out eight independent regions of evolution, upward of twenty developing organs, upward of thirty degenerating organs. A more exhaustive analysis would increase this list tenfold. Now, where chance variation should produce an increase in size in all the developing organs, and a decrease in size of all the degenerating organs, and an average size in all the static organs, we would have all the conditions favoring survival. But the chances are infinity to one against such a combination occurring unless the tendencies of variation are regulated and determined, as

Lamarckians suppose, by the inheritance of individual tendencies. But may not the favorable variations in the body be grouped to either outweigh or underweigh the unfavorable variations? This would be possible if combinations occurred, but we can readily see that combinations, such as we observe in the separate elements in the foot alone, completely neutralize each other so far as "survival" is concerned; how the foot would neutralize the hand, or the foot and hand would neutralize the lumbar region.[1]

It is this consideration of single organs, the observation of their independent history, the rise of new compound organs, by steady growth from infinitesimal beginnings of their separate elements, the combined testimony of anatomy and palæontology which force us to regard the theory of evolution by the natural selection of chance variations as wholly untenable. With the utmost desire to regard the discussion in as fair a spirit as possible, the explanations offered by the adherents of Weismann's doctrine strike me as strained, evasive, and illogical.[2]

We can, however, by no means undervalue or dispense with natural selection, which must be in continuous operation upon every character of sufficient importance to weigh in the scale of survival. I need hardly remind you that this selecting principle was first discovered in 1813 by Dr. W. C. Wells, of Charleston, in connection with the immunity from certain tropical diseases enjoyed by negroes and mulattoes.[3]

The eliminating factor in selection is illustrated almost daily in cases of appendicitis. I regret I have not had time to ascertain whether or not this disease is considered due purely to accident or to congenital variation in the aperture of the appendix, which favors the admission of hard objects. If so, modern surgery is only benefiting the individual to the detriment of the race by its efficient preventive operations;

[1] I have expanded this idea fully in recent papers upon the theory of evolution of the horse. See "Are Acquired Variations Inherited?" AMERICAN NATURALIST, February, 1891.

[2] See Weismann's last essay, Retrogressive Development in Nature, Biol. Mem., trans., in press.

[3] See Introduction of Darwin's Origin of Species.

and every individual who succumbs to this disease can reflect with melancholy satisfation that he does so *pro bono publico.*

Conclusions as to the Factors of Evolution.—The conclusions we reach from the study of the muscular and skeletal systems are therefore as follows: 1st. That individual transformism in the body is the main determinant of variations in the germ-cells, and is therefore the main cause of definite progressive or retrogressive variations in single organs. 2d. That evolution in these organs is hastened, where all members of the race are subject to the same individual transformism. The contrast between the rate of individual transformism and race transformism is due to the strong conservative forces of the germ-plasma. 3d. That evolution is most rapid where variations are of sufficient rank to become factors in survival. Then selection and use-inheritance unite forces, as active progressive principles opposing the conservative principle in the germ-plasma. 4th. That fortuitous and chance variations also arise from disturbances in the body or germ-cells; they may be perpetuated, or disappear in succeeding generations.

Applying these views to variation there should, theoretically, appear to be just those two distinct classes of anomalies in the human body which we have seen actually occurring. First, those in the path of evolution, arising from perfectly normal changes in the somatoplasm and germ-plasm. Second, those wholly unconnected with the course of evolution, arising fortuitously or from abnormal changes in the somatoplasm or germ-plasm; to this head may be attributed the whole scale of deformities. Thus transformism and de-formism should be kept distinct in our minds. Nevertheless the facts of de-formism contribute the strongest body of evidence which we can muster at present to prove that there does exist a relation between the somatoplasm and germ-plasm which renders transformism possible.

The Relations between the Somatoplasm and Germ-plasm.—We have seen reasons to take a middle ground as to the distinct specific nature of the body cells and germ cells, and this position is, I think, strengthened the more broadly

we extend our inquiry into all the fields of protoplasmic activity.

There are three questions before us.

1. What is the evidence that the germ-plasm and somatoplasm are distinct?

2. What is the specific nature of the germ-plasm?

3. What is the nature of the relations which exist between the two?

1. The *separation of the germ-plasm* is in the regular order of evolution upon the principles of physiological division of labor. The unicellular organisms combine all the functions of life in a single mass of protoplasm, that is, in one cell. In the rise of the multicellular organisms the various functions are distributed into groups of cells, which specialize in the perfecting of a single function. Thus the reproductive cells fall into the natural order of histogenesis, and the theory of their entire separation is more consistent with the laws governing the other tissues than the theory which we find ourselves obliged to adopt, that while separate they are still united by some unknown threads with the other cells.

The morphological separation of what we may call the race-protoplasm becomes more and more sharply defined in the ascending scale of organisms. Weismann's contention as to the absolutely distinct specific nature of the germ-plasm and somatoplasm has, however, to meet the apparently insuperable difficulty that in many multicellular organisms, even of a high order, the potential capacity of repeating complex hereditary characters, and even of producing perfect germ-cells, is widely distributed through the tissues.

For example, cuttings from the leaves of the well-known hot-house plant, the begonia, or portions of the stems of the common willow-trees, are capable of reproducing complete new individuals. This would indicate either that portions of the germ-plasm are distributed through the tissues of these organisms, or that each body-cell has retained its potential quota of hereditary characters.

Among the lower animals we find the same power; if we cut a hydra or bell-animalcule into a dozen pieces each may

reproduce a perfect new individual. As we ascend in the animal scale the power is confined to the reproduction of a lost part in the process known as recrescence. As you well know, in the group to which the frog and salamander belong, a limb or tail, or even a lower jaw may be reproduced. The only logical interpretation of these phenomena is that the hereditary powers are distributed in the entire protoplasm of the organism, and the capacity of reproduction is not exhausted in the original formation of the limb, but is capable of being repeated. There has been considerable discussion of late as to the seat of this power of *recrescence*. It seems to me not impossible that in the vertebrates it may be stored in the germ-cells, and it would be very interesting to ascertain experimentally whether removal of these cells would in any way limit or affect this power; we know that such removal in castration or ovariotomy sometimes profoundly modifies the entire nature of the organism, causing male characters to appear in the female, and female characters to develop in the male.

So far as man is concerned it has been claimed by surgeons that genuine recrescence sometimes occurs; for example, that a new head is formed upon the femur after exsection; but my friend Dr. V. P. Gibney informs me that this is an exaggeration, that there is no tendency to reproduce a true head, but that a pseudo-head is formed which may be explained upon the principle of regeneration and individual transformism by use of the limb.

Pflüger's opinion is that recrescence does not indicate a storage of hereditary power, that there is no pre-existing germ of the member, but that the re-growth is due to the organizing and distributing power of the cells at the exposed surface, so that as new formative matter arrives it is built up gradually into the limb. This view would reduce recrescence to the level of the *regeneration* process, which unites two cut sections of the elements of a limb in their former order. It is partly opposed to the facts above referred to, which seem to prove the distribution of the hereditary power. Yet it seems to me quite consistent to consider these three processes—*a*, reproduction of a new individual from every part; *b*, recrescence of a new

member from any part; *c*, regeneration of lost tissues—as three steps indicating the gradual but not entire withdrawal of the reproductive power into the germ-cells.

I have not space to consider all the grounds which support the view of the separation of the germ-cells in man. Some of the more prominent are the very early differentiation of these cells in the embryo, observed with a few exceptions in all the lower orders of animals, and advancing so rapidly in the human female that several months before birth the number of primordal ova is estimated at seventy thousand, and is not believed to be increased after the age of two and a half years. The most patent practical proof is that we may remove every portion of the body which is not essential to life and yet the power of complete reproduction of a new individual from the germ-cells is unimpaired. Among the many reasons advanced for pensioning the crippled soldiers of our late war you never hear it urged that their children are incapacitated by inheritance of injuries. The strongest proof, however, rests in the evidence I have already cited from heredity of the extraordinary stability of the germ-cells, which is the safeguard of the race.

2. The *specific nature of the germ-plasm* must be considered before we consider its relations. Wherein lies the conservative power of the germ-plasm, and in what direction shall we look for its transforming forces? You see at once that marvellous as is the growth of cells in other tissues, the growth of the germ-cell is still more so.

We find it utterly impossible to form any conception of the contents of the microcosmic nucleus of the human fertilized ovum, which is less than $\frac{1}{2500}$ of an inch in diameter, but which is, nevertheless, capable of producing hundreds of thousands of cells like itself, as well as all the unlike cells of the adult organism. We can only translate our ideas as to the possible contents of this nucleus in the terms of chemistry and physics.[1]

Spencer[2] assumed an order of molecules or units of proto-

[1]See Ray Lankester, Nature, July 15, 1876.

[2]Principles of Biology, vol. i, p. 256.

plasm lower in degree than the visible cell-units, to the internal or polar forces of which and their modification by external agencies and interaction, he ascribes the ultimate responsibility in reproduction, heredity and adaptation. This idea of biological units seems to me an essential part of any theory; it is embodied in Darwin's "gemmules," in Haeckel's "plastidules," yet, as Lankester says, the rapid accumulation of bulk is a theoretical difficulty in the material conception of units. In the direction of establishing some analogy between the repetition power of heredity and known function of protoplasm, Haeckel[1] and Hering[2] have likened heredity to memory, and advanced the hypothesis of persistence of certain undulatory movements; the undulations being susceptible of change and therefore of producing variability, while their tendency to persist in their established harmony is the basis of heredity. Berthold, Gautier and Geddes[3] have speculated in the elaboration of the idea of metabolism; the former holding the view that "inheritance is possible only upon the basis of the fundamental fact that in the chemical processes of the organism the same substances and mixtures of substances are reproduced in quantity and quality with regular periodicity."[4]

I have merely touched upon these speculations to show that the unknown factors in heredity are also the unknown factors in operation in living matter. All we can study is the external form and conjecture that this form represents matter arranged in a certain way by forces peculiar to the organism. These forces are exhibited or patent in the somatic cells; they are potential or latent in the germ-cells.

The last stage of our inquiry is as to the mode in which the action of habit or environment upon the somatic cells can be brought to bear upon the germ-cells.

[1]Perigenesis der Plastidule oder die Wellenzeugung der Lebenstheilchen. Jena, 1875.

[2]Ueber d. Gedächtniss als eine allgemeine Function d. organischen Materie. Vienna, 1870.

[3]See also Thomson, op. cit., p. 102.

[4]Berthold: Studien über Protoplasma-Mechanik. Leipzig, 1886.

The Nature of the Relation Between the Body-cells and Germ-cells.—I have already shown that we are forced to infer that such a relation exists by the facts of evolution, although these facts show that the transmission of normal tendencies from the body to the germ-cells is ordinarily an extremely slow process.

Virchow[1] says every variation in race character is to be traced back to the pathological condition of the originator. All that is pathological is not diseased, and inheritance of a variation is not from the influence upon one individual necessarily, but upon a row of individuals. This is in the normal condition of things. In the abnormal condition the rate of transmission may be accelerated.

Does this transmission depend upon an interchange of material particles or upon an interchange of forces, or both?

There are three phenomena about which there is much scepticism, to say the least, which bear upon the question of a possible interchange of forces between the body and germ-cells. These are the inheritance of mutilations, the influence of previous fertilization, and the influence of maternal impressions. They are all in the quasi-scientific realm, which embraces such mental phenomena as telepathy. That is, we incline to deny them simply because we cannot explain them.

Mutilations.—Since the publication of Weismann's essays the subject of inherited mutilations has attracted renewed interest. I would first call attention to the fact that this matter has only an indirect bearing, for a mutilation is something impressed upon the organism from without; it is not truly "acquired;" the loss of a part by accident produces a sudden but a less profound internal modification of the organism than the loss of a part by degeneration. Most of the results are negative; many of the so-called "certain" cases prove upon investigation to be mere coincidences. Weismann[2] himself experimented upon white mice, and showed that nine hundred and one young were produced by five generations of arti-

[1]Ueber den Transformismus, Archiv f. Anthropologie, 1888, p. 1.

[2]Biological Memoirs, p. 432.

ficially mutilated parents, and yet there was not a single example of a rudimentary tail or of any other abnormality in this organ. The cases of cleft ear lobule have recently been summed up.[1] Israel reports two cases of clefts in which the parent's ears were normal. Schmidt and Ornstein report affirmative cases. His shows that an affirmative case, cited by V. Zwieciki, is merely an inherited peculiarity. The entire evidence is unsatisfactory, and upon the whole is decidedly negative.

Not so, however, in cases where the mutilation results in a general disturbance of the normal functions of different organs, as in the experiments conducted by Brown-Séquard[2] upon guinea-pigs, in which we see "acquired variation" intensified. In these, abnormal degeneration of the toes, muscular atrophy of the thigh, epilepsy, exophthalmia, etc., appeared in the descendants of animals in which the spinal cord or sciatic nerve had been severed, or portions of the brain removed. It was also shown that the female is more apt to transmit morbid states than the male; that the inheritance of these injuries may pass over one generation and reappear in the second; that the transmission by heredity of these pathological results may continue for five or six generations, when the normal structure of the organs reappears. These cases, which are incontestable, at first sight appear to establish firmly the transmission of acquired characters; they were so regarded by Brown-Séquard. These lesions act directly upon the organs, and the abnormal growth in these organs appears to be transmitted. But can they not be interpreted in another way, namely, that the pathological condition of the nerve-centers has induced a direct disturbance in those portions of the germ-cells which represent and will develop into the corresponding organs of the future offspring?

Previous Fertilization.—Consider next the influence exerted upon the female germ-cell by the mere proximity of the male

[1] Journal of Anatomy and Physiology, 1891, p. 433.

[2] Comptes-Rendus, March 13, 1882. These experiments have been confirmed by Obersteiner.

germ-cell, as exhibited in the transmission of the characteristics of one sire to the offspring of a succeeding sire observed in animals, including the human species, also in plants. The best example is the oft-quoted case of Lord Morton's mare, which reproduced in the foal of a pure Arab sire the zebra markings of a previous quagga sire.

Some physiologists[1] have attempted to account for these remarkable indirect results from the previous fertilization or impregnation, by the imagination of the mother having been strongly affected or from interchange between the freely intercommunicating circulation of the embryo and mother, but the analogy from the action in plants (in which there is no gestation but early detachment and development of the fertilized cells) strongly supports the belief that the proximity of male germ-cells acts directly upon the female cells in the ovary. All that we can deduce from these facts is that in some manner the normal characteristics and tendencies of the ova are modified by the foreign male germ-cells without either contact or fertilization.

Maternal Impression.—The influence of maternal impressions in the causation of definite anomalies in the fœtus is largely a matter of individual opinion.

It is denied by some high authorities, led by Bergman and Leuckart.[2] Most practitioners, however, believe in it, and I need hardly add that it is a universal popular belief,[3] supported by numerous cases. I myself am a firm believer in it, from evidence which I am not free to publish. The bearing which the subject has upon this discussion is this: if a deviation in the development of a child is produced by maternal impression we have a proof that a deviation from normal hereditary tendencies can be produced without either direct vascular or nervous continuity.

We see an analogy between the experiments of Brown-Séquard, the influence of the previous sire, and the maternal

[1] See the cases cited by Ribot and Darwin: Animals and Plants under Domestication, vol. i, p. 437.

[2] Handwörterbuch der Physiologie, Wagner, Artikel "Zeugung," Leuckart.

[3] See Medical Record, October 31, 1891, an article by Joseph Drzewiecki, M. D.

influence. Neither, in my opinion, directly supports the theory of transmission of acquired characters, for they do not prove that normal changes in the body-cells directly react upon the germ-cells; they all show that the *typical hereditary development of single organs may be diverted by living forces which have no direct connection* with them according to our present knowledge.

What the nature of these forces is I will not undertake to say, but I believe we must admit the existence of some unknown force, or rather of some unknown relations between the body-cells and germ-cells.

A year ago, recognizing fully the difficulty of advancing any theory of heredity which would explain the transmission of acquired characters, I came to the following result: "It follows as an unprejudiced conclusion from our present evidence that upon Weismann's principle we can explain inheritance but not evolution, while with Lamarck's principle and Darwin's selection principle we can explain evolution, but not, at present, inheritance. Disprove Lamarck's principle and we must assume that there is some third factor in evolution of which we are now ignorant."

In this connection it is interesting to quote again from my colleague, Professor E. B. Wilson. He writes that the tendency in Germany at present is to turn from speculation to empiricism, and this is due partly "to the feeling that the recent wonderful advances in our knowledge of cell phenomena have enormously increased the difficulties of a purely mechanico-physical explanation of vital phenomena. In fact, it seems that the tendency is to turn back in the direction of the vital-force conception. . . . As Boveri said to me recently, 'Es gibt zu viel Vorstand in der Natur um eine rein mechanische Erklärung der Sache zu ermöglichen.'"

In the final lecture we turn to the forces exhibited in the germ-cells.

NOTE.—Bearing upon the experimental evidence for the hereditary transmission of multilations, I have recently received, through Dr. Charles E. Lockwood, of New York, a letter,[1] in regard to some experiments upon mice, which were continued over more generations than those of Weismann, and with affirmative results:

"I selected a pair of white mice on account of their rapid breeding. I bred them in and in for ninety six generations, as they breed every thirty days, and when they are thirty days old they are able to reproduce themselves. I destroyed all sickly and defective ones by breeding only the fittest. I bred all disease out of them, and had a pure-blooded animal, larger and finer every way than the original pair. In breeding their tails off, I selected a pair and put them in a cage by themselves, and when they had young I took the young and clipped their tails off. When old enough to breed I selected a pair from the young and bred them together, and when they had young I clipped their tails. I continued this breeding in and in, clipping each generation, and selecting a pair of the last young each time, in seven generations. Some of the young came without tails until I got a perfect breed of tailless mice. I then took one with a tail and one without a tail and bred them together, and by changing the sexes each time—a male without a tail, a female with a tail, and next a female without a tail, and a male with a tail—I was finally rewarded with all-tail mice."

There is such general scepticism now in regard to the inheritance of mutilations that it will be necessary to repeat such experiments as these in some well-known physiological laboratory. As told above, they seem to be trustworthy, but facts which go against a theory must be doubly attested.

[1]From A. J. S. Shiddell, Lexington, Ky.

SUPPLEMENTARY INVESTIGATION AT TICK ISLAND.

By Clarence Bloomfield Moore.

In the February, 1892, number of the American Naturalist, I gave an account of certain investigations made by me at Tick Island, Volusia Co., Florida. The readers of that article will recall that into the great sand mound at that place numerous trenches and shafts were made, resulting in the discovery of a number of objects of interest archæologically, and the formation by me of a theory as to the construction of the mound. This theory has not in any way been modified by a supplementary investigation continued with a party of seven assistants through January 15th, 16th, 18th, 19th, 1892.

The mound is built upon a circular heap of shell converging to an apex at the center. This heap was probably brought from neighboring shell deposits or a low heap already formed was used for the purpose. I am inclined to believe, however, that the shell was brought with a view to the formation of a solid base in the swamp, since irregular ridges and elevations of shell do not extend beyond the margin of the mound as is so often the case where sand mounds have been piled upon previously existing shell heaps. It will be remembered that a ridge of pure white sand with sloping ends ran north and south almost through the mound, this ridge being covered with brown sand having at times a certain admixture of shell, and that this covering of brown sand, comparatively small at the extremities of the ridge, attained great thickness on its sides to the east and west thus completing the conical shape of the mound.

On the western side of the mound, beginning at the margin of the base, was made a diverging trench, 8 ft. in breadth at the start, 54 ft. in length, or 4 ft. beyond the center of the mound. At 44 ft. from the starting point the breadth of the trench was 14 ft. and its depth 10 ft. From this point to the end the breadth of 14 ft. was maintained to a depth of 6 ft.

and two inches through the brown sand and converging to a width of 10 ft. through the white sand. No effort was made to penetrate the compact mass of shell at the base of the mound save at one or two points, where the usual debris of the shell heaps was found. The trench, when digging was discontinued (having followed the upward slope of the shell base) was 11 ft. and 10 in. in depth, of which the white sand above the shell was 5 ft. 8 in. and the upper layer or brown sand 6 ft. and 2 in., leaving to the shell base a thickness of 5 ft. and 5 in. above the level of the margin of the base of the mound.

At a distance of 30 ft. from the start the side of the white sand ridge was encountered, the trench up to that point running through the brown sand layer. The first skeleton was met with 24 ft. from the beginning of the trench. Previous to this many bones entirely disconnected, and mainly the larger bones of the skeleton, were found. With the exception of the articular portions the bones were not affected by decay to a marked extent as were those subsequently found covered by the white sand. It is possible that they are of a later period or that the lime salts from the admixture of shell have contributed to their preservation. As before stated these bones were not in association with each other but must not be confounded with the form of burial practiced on the east and west coasts of Florida and in at least one mound on the St. John's, namely Ginn's Grove, south of Lake Monroe, where piles of larger bones previously exposed were found buried horizontally surmounted by the skulls. Neither were the bones in any way crushed, split or charred, suggestive of the methods of many of the shell heaps of the St. John's River, nor did they show any signs of the breakage of necessity occurring when decayed bones are disturbed by the aid of implements. In the plateau constituting the summit of the mound were flexed burials (probably intrusive) in anatomical order and others were numerous on the slope bordering the plateau. Unless the disconnected bones were washed down when the mound was larger and not as at present held compactly together by the roots of vegetation, I can form no hypothesis to offer as to their condition when found.

In the white sand ridge as before, lying upon the shell base, were found burials in anatomical order, while differing from our former investigation some interments were met with in the white sand considerably above the shell.

Owing to decay and to the pressure of sand no crania were saved though great pains were taken and preservative agents were at hand. In this connection I may say that from seventeen burial mounds on or near the St. John's River more or less thoroughly explored by me, I have taken but one whole skull in good condition. So great is the pressure exerted by heavy masses of sand that often the shafts of tibiæ found at the base of burial mounds have been crushed. Such being the case it can readily be conceived how slender are the chances to recover a skull in perfect condition.

As before no mark of decay was found in any of the teeth though many showed signs of excessive wear. Many of the bones gave evidence of having served in frames endowed with great muscular strength, the ridges being very noticeable.

In the femurs the linea aspera was prominent, some with a tendency towards the "pilaster." But two femurs of the many found possessed the articular portions sufficiently intact to allow measurement as to length.

Of the two of which measurements were taken the length of one was 18 in. (tape) to the tip of the great trochanter and that of the other $16\frac{1}{2}$ in. (tape) to the upper margin of the head. Taking .275 as the ratio of the length of the femur to the entire stature it will be seen that no great height is indicated. Of course no general rule can be drawn from two cases but a large number of femurs exhumed from the Tick Island mound with articular portions more or less decayed were at least in sufficiently good condition to allow a fairly close estimate and of these and of hundreds of others met with in burial mounds and shell heaps in Florida I can say that none indicated a stature of six feet. Four tibiæ exhumed intact measured respectively $14\frac{1}{2}$ in., $12\frac{3}{8}$ in., 12 5-6 in., and $14\frac{1}{2}$ in. in length (tape).

Platycnemism.

It will be remembered that in recent years a marked lateral flattening of the tibiæ has been noticed as a characteristic of early and savage races in various parts of the world. This flattening exists in a varying degree and is frequently found in connection with anterior curvature. Measurements are usually made where the nutrient artery enters the bone and the percentage of the lateral diameter as compared with the antero-posterior diameter, ascertained.

According to Topinard (Anthropology p. 299 et seq.) the peculiarity was first commented upon in relation to the family buried at Cro-Magnon. He furthermore states that in two hundred Parisian tibiæ dating from the fourth to the tenth centuries 5.25% were platycnemic while 14% were bent. Unfortunately the degree of flattening is not given.

Prof. Wyman (Fresh Water Shell Mounds of the St. John's River, Florida, page 67) says "the proportion of the transverse to the fore and aft diameter in whites as compared with Indians, comprising mound builders, is as follows: The fore and aft diameter being taken as 1.00 the transverse in twelve whites 0.70, in twelve from the mounds of Florida 0.64, in seven from mounds in Kentucky 0.63, in two from Osceola mound (a shell heap now known as Crow's Bluff) 0.59, three from the mound on the St. Clair River 0.60, five from the mound on River Rouge 0.53, in an Aleutian islander 0.56, in an Eskimo 0.60, in a Californian 0.53, in a tibia from the Merrimac River 0.60, in a Peruvian 0.50, in a Gorilla (male) 0.57, Gorilla, (female) 0.71, Chimpanzee 0.65." It must be borne in mind that Prof. Wyman's researches into the burial mounds of Forida were very superficial (see foot-note Fresh Water Shell Mounds, page 47) and his measurements probably relate to tibiæ of intrusive burials, though between the tibiæ of later Indians and those from original interments in various sand mounds of the St. John's the difference in flattening is not marked.

Another point carefully to be borne in mind is that the measurement of a single tibia amounts to little in the estab-

lishment of a race characteristic. Between the maximum and minimum degree of flattening among the tibiæ found at Tick Island was a difference of 31%.

Prof. Edward S. Morse (Shell Mounds of Omori) gives the percentage of nine recent Japanese tibiæ as 0.74, one tibia from the shell heaps of Omori 0.62, one from a shell heap in the province of Higo 0.5002.

In Michigan platycnemism has been noticed to a marked degree. Mr. Henry Gillman (Smithsonian Report for 1873 page 368) cites nine tibiæ from a number found by him in the great mound on the Rouge River and in the circular mound on the Detroit River. Of these the average was 0.486, the lowest being 0.402.

It is to be regretted that the average of the entire number found is not given.

Of the very many tibiæ exhumed at Tick Island fifty-five were in condition for measurement, many being broken at a point too low for determination, while others were crushed. It is of course apparent that all tibiæ must be discarded where a lateral flattening exists through causes acting on the bone after interment, since measurements made without due care in this respect would give and unfairly, a very low percentage to the lateral diameter.

All measurements are made with calipers in hundredths of an inch. Of the fifty-five tibiæ the least platycnemic measured transversely .96 inch and antero-posteriorly 1.16 inch, a percentage of 82, while the two lowest (now in my possession) were respectively .72x1.41 and .75x1.45 or 51% and 51.7%, the average for the fifty-five tibiæ being 63.9%.

In this connection it is possible that statistics as to tibiæ found by me in other mounds of the St. John's may be useful for purposes of comparison.

	Per cent.
Burial mound at Ginn's Grove near Lake Jessup; three tibiæ, intrusive burials, average	64.77
Thirty-three tibiæ, original burials from base of mound average	64.9

Persimmon mound, about twenty miles south of Lake Harney; burials in shell heap, 4 tibiæ	58.3
Orange mound, near Persimmon mound; original burials in shell, three tibiæ	58.
Raulersons, south-eastern end of Lake Harney; burials (?) nine tibiæ	62.5
Small burial mound, Stark's Grove, Lake Beresford; one tibia	84.
Shell heap, near Econlockhatchee Creek; burials (?) three tibiæ	59.9
Burial mound on Blue Creek, near Volusia; one tibia	64.8
Burial mound, Thornhill Lake, near Lake Jessup; two tibiæ, three feet from surface	60.4
Three tibiæ, original burials	65.
Burial mound opposite Huntoon Island; original burials, five tibiæ	62.
Intrusive burials, five tibiæ	64.
Burial mound, Fort Taylor, Lake Winder; original burials, four tibiæ	64.8
Mulberry mound, near Lake Poinsett; original burials, sixty-six tibiæ	66.2
Bluffton, sand mound; intrusive burials, three tibiæ	70.7

Perforation of the Humerus.

The perforation of the wall between the fossæ at the lower end of the humerus seems to be a characteristic of early and unmixed races. The perforation does not necessarily occur in both humeri of the same person. Mr. Henry Gillman (American Naturalist, 1875, page 427) noticed it in the mounds on the Detroit and Rouge Rivers, Michigan, but unfortunately bases the percentage of its occurrence on an estimate.

Topinard (Anthropology page 298 et seq.) furnishes an interesting table as to the frequency of the occurrence of the perforation of the humerus at various periods in France.

Number of humeri.		Per cent.
66	Caverne de l'Homme Mort (La Lozere) . . .	10.6
368	Dolmens of La Lozere	10.6
128	Stations of Vaureal, Orrouy and Chamans . .	21.7

(Polished stone period.)

41	Pre-gallic station of Campans	12.5
42	Mountaineers of the Ain (5th Century)	27.7
69	French Basques	13.4
200	Parisians of the 4th to the 10th century . . .	5.5
218	Parisians of the middle ages	4.1
150	Parisians anterior to the 17th century	4.6
1000	(?) Merovingians of Chelles	2.0

It is well to remember in examining the olecranon fossa that the partition, if it exists, is often extremely thin and when sand or earth is removed with a pointed instrument an artificial perforation may result. In the humeri examined by me at Tick Island and other burial mounds, data as to which are furnished for comparison, all foreign substances were removed from the cavity with the aid of a soft brush. It is therefore believed that none but pre-existing perforations are enumerated.

				Per cent.
46	Humeri, Tick Island,	16	Perforated . . .	34.8
42	Humeri, Ginn's Grove,	9	Perforated . . .	27
7	Humeri, Persimmon mound,	4	Perforated . . .	57
4	Humeri, Orange mound,	0	Perforated . . .	
19	Humeri, Raulerson's	8	Perforated . . .	42
2	Humeri, Lake Beresford	0	Perforated . . .	
3	Humeri, Econlockhatchee Creek	1	Perforated . . .	33.33
9	Humeri, Thornhill Lake	6	Perforated . . .	66.66
14	Humeri, opposite Huntoon Island	7	Perforated . . .	50
4	Humeri, Fort Taylor	1	Perforated . . .	25
76	Humeri, Mulberry mound	40	Perforated . . .	52.7
3	Humeri, Bluffton	3	Perforated . . .	100.
229		95		41.5

Pathological Specimens.

In the former excavations a number of tibiæ were found with marked anterior curvature and increase in the circumference of the bone with roughened surface. But one of this nature was met with upon the last visit to Tick Island, at five and a half feet from the surface and twenty-five feet from the margin of the base of the mound.

Perforated Crania.

One cranium with perforation at parietal eminence .7 in. antero-posteriorly and .6 in. transversely was the only skull found showing perforation and in this case the uneven margin showed it to be the result of a blow from a pointed instrument, having nothing in common with the round and even perforations found in fragments of two crania during previous investigations.

Pottery.

Throughout the entire upper stratum were found fragments of pottery, the large majority undecorated but some ornamented with parallel lines.

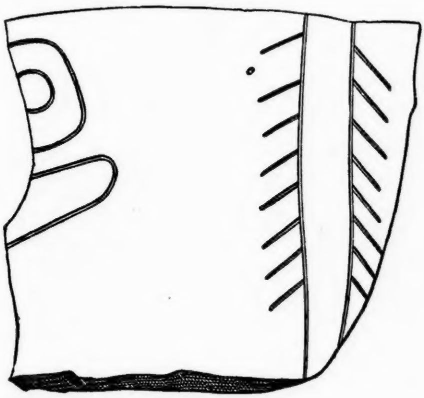


Fig. 1.

In the white sand layer were found bits of pottery in immediate association with every skeleton, many plain, some rudely ornamented in the same manner as those found in the stratum above.

One piece found near the bottom of the white sand layer bore a pattern not met with by me in any other sand mound or in several hundred excavations in shell heaps on or near the St. John's. (Fig. 1.)

At forty-two feet from the circumference of the base and ten feet from the surface of the mound, at the bottom of the white sand layer, with the crumbling bones of a skeleton was found in perfect condition a small earthenware pot with sides deeply grooved, of a pattern entirely unfamiliar to me. (Fig. 2.)

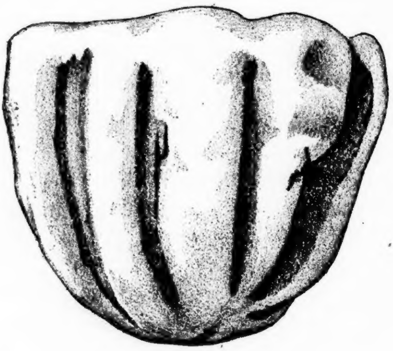


FIG. 2.

Pottery decorated with knobs, of which several specimens were found last year, was not met with during these supplementary investigations at Tick Island nor have I seen them on or below the surface in mound or shell heap on the St. John's River between Palatka and Lake Washington, a distance by water of about three hundred (300) miles. This knobbed pottery was sent to the Peabody Museum of Archæology and a report from the very high authority there could not fail to be of interest.

Fragments of Pottery Shaped in the Form of Spear and Arrow Points.

Reference was made to this subject in my former paper.

During the supplementary investigations many bits of pottery broken in triangular shapes, were found particularly with the burials in the lower sand layers. At least two fragments of pottery were found giving unmistakable evidence of the arrow-head shape having been conferred through design, the sides being chipped rudely to imitate the point of the arrow. Since the writing of my first paper I have secured so much evidence tending to show that the Indians of the earlier burial mounds substituted with their burials the imitation for the real in the way of arrow-heads and spear points that I regard the question as virtually settled.

In the mound at Ginn's Grove, south of Lake Monroe, the custom was very apparent; the great sand mound on Lake Winder emphasized the fact, while in the small burial mound discovered by me near Lake Poinsett nearly every piece of pottery was broken or chipped in the form I have described.

Implements, Ornaments, Etc.

About three feet below the surface, not in association with any skeleton, a very beautiful polished celt $8\frac{1}{2}$ in. in length was brought to light. This implement cannot however be regarded as belonging to the period of the construction of the mound.

Other objects of interest were:—a piece of coquina rudely fashioned in the form of a spear head; two flakes of flint; portion of "conch" shell; two pieces of madrepore; shell implements of doubtful attribution; handful of shell beads with skeleton of child five feet below the apex of the mound. With the beads were a fragment of calcined bone and a flake of flint. Two feet distant was the claw of a large animal, probably a bear. On the shell base not far from the center of the mound were found a number of pieces of what Professor Putnam pronounces to be soft coal and furthermore states that

any previous discovery of this commodity in Florida is unknown to him.

Possible Indications of Cannibalism.

At the bottom of the white sand ridge, nine feet four inches from surface and thirty-five feet from circumference of the base of the mound, was found a skeleton very badly decayed. Immediately below were apparently the remnants of a feast consisting of a fragment of charred bone and four pieces of bone showing no action of fire, of which two were human. These fragments entirely unassociated with any others were in a better state of preservation than the skeleton immediately above owing to the shell below them. In every way they resembled the bones of the shell heaps.

From one fragment, a portion of the lower jaw of a child, every tooth was missing. While no definite conclusion can be arrived at in this connection it may be permissible to suggest that the process of boiling would be conducive to the loosening of the teeth. No other isolated human bones were found in the white sand layer.

An Intrusive Burial.

As before stated intrusive burials were frequent in the Tick Island Mound. A description of one of these may be of interest. It will be rememberd that flexed burials vary greatly in the mounds of the St. John's as to the degree and form of flexion.

Near the apex of the mound, eighteen inches from the surface, lay a skeleton in a fairly good state of preservation, though the skull was crushed beyond recovery. The body lay belly down, the face rotated to the right with the neck flexed in that direction. The left lower extremity had the thigh flexed to the abdomen, the leg flexed on the thigh with the foot extending downward. The right lower extremity had the thigh abducted and rotated externally to the transverse plane of the body and flexed to a right angle, the leg flexed on the thigh and the foot extended. The arms were somewhat

disturbed by digging but enough was seen to show that they were not folded on the abdomen as is often the case. The skeleton was of a man, the length of one femur was 16½ in. One humerus was perforated, of the other the portion necessary for determination was decayed. One tibia was 14½ in. in length. The lateral diameter was .82 in., the fore and aft measurement at the same point 1.44 in. giving a percentage of 57.

Comparative Age of the Mound.

As was the case during previous investigations no object indicating intercourse with the whites was found. Taking into consideration the quantity and quality of the pottery it is probable that the Tick Island Mound is of more recent construction than certain other burial mounds on the St. John's in which no pottery is met with, for judging from its almost universal association with skeletons in so many mounds we must consider it probable that no cause save ignorance of the art of its manufacture can explain its absence in other burial mounds.

In a careful investigation of the shell heaps of the St. John's made by me, extending to Lake Washington, during which several hundred excavations were made in upwards of sixty localities, nothing in anyway indicating the presence of the whites was ever brought to light. It will be remembered that Prof. Wyman's investigations had the same result. There are then strong reasons to believe that the last shell heap was completed prior to the arrival of Europeans.

In a large shell heap of the upper St. John's I was fortunate enough to discover under several feet of shell a stratified burial mound, particulars of which I hope to publish later. From this discovery and from the fact that presence or absence of pottery in the mounds as a rule coincides with neighboring shell deposits I am inclined to believe that the larger burial mounds including Tick Island are contemporary with the later shell heaps at least and were abandoned prior to the coming of the whites.

EXPERIMENTAL EMBRYOLOGY.

By E. A. Andrews.

(*Continued from May number, p. 382.*)

Schultze[1] holds that the black pole becomes the dorsal region on which the medullary folds are formed, and that the blastopore arises and remains near the tail end of the animal, at the highest part of the white yolk, when the egg is, as is normal he says, inclined about 45°. There is, however, a rotation of the egg about a horizontal axis at right angles to the plane of symmetry, a rotation that carries blastopore downward 80°. Yet this is compensated for by a reverse rotation upward of 90°, so that there is little absolute change after the blastopore is closed; the ingrowth of entoderm during gastrulation being, he surmises, the cause of these revolutions, since the egg is thereby overbalanced, first one way then the other.

After this digression beyond the limits of experimental embryology into the hazy ground of unverified hypotheses we may turn attention to a work rich in experimentation, the only French contribution that we are acquainted with, the very suggestive work upon the ascidian egg by Chabry,[2] whose paper appears not to have met with the appreciation it deserves.

Having made a very careful study of the cleavage phenomena in normal eggs of *Ascidia aspera* in the summer seasons of 1884 and 1886, the author was in a position to appreciate the remarkable abnormalities sometimes occurring in the development of this ascidian. As these abnormalities to some extent correspond with the results of artificial treatment of the eggs, some account of them cannot be passed over here,

[1]O. Schultze, Ueber Axenbestimmung des Froshembryo. Biol. Centb., vii, 1888, pp. 577–588.

[2]Contribution a l'embryologie normale et tératologique des ascidies simples. Jour. de l'Anatomie, 1887, pp. 167–313, plates 18–22.

especially as they furnish in themselves interesting facts bearing upon our interpretation of embryological phenomena.

Without apparent cause, unless, as the author inclines to believe, old age of the adults is here concerned, all the ascidians obtained late in one season gave rise to abnormal eggs, few amid the entire number developing in the normal way for any length of time. These natural monsters or deficient eggs can be explained only on the assumption that the parent organism made them imperfect from the start, or at least furnished abnormal conditions of environment for them before they were laid, as they may develop in the same aquaria with other eggs that follow a typical series of changes without any abnormalities. Moreover the eggs from one adult often show some common defect or tendency to be abnormal in certain lines, though there is great individual difference between even these eggs.

These abnormalities of unknown or natural origin are classified under the following seven heads: 1st, change from the normal position of the cleavage planes; 2d, retarded cleavage; 3d, cleavage confined to the nuclei; 4th, absence of cleavage; 5th, fusion of cells; 6th, unusual migrations of cells; 7th, death of cells. The presence of one or more of the above factors and their various combinations gives rise to the numerous monstrosities found during the cleavage, gastrulation and larval life; moreover one abnormality gives origin to others later on in development, so that larvæ with great defects are classed as cases of death, for instance, of one or more cells in an early stage.

In addition to the various abnormalties thus classified some other forms, such as a larva with well-developed double or bifid tail, were observed but not traced back to any of the above seven categories.

The interest of these various modes of irregularity lies, for our present purposes, in the fact that all seven conditions have been artificially brought about by M. Chabry by various mechanical stimuli applied either to the egg of the ascidian or to that of the sea urchin. The results upon the ascidian were for the most part obtained by means of traumatic inter-

ference, and lead only to the death of cells. These abnormalities are the ones described in the sequel, while other classes of abnormalities are either obtained by other methods applied to the egg of the same animal or else refer to the egg of the sea urchin, *Strongylocentrotus lividus*, and are not mentioned in detail in the present paper.

Wounding the cells of *Ascidia aspera* in early stages leads to the death of these cells and to subsequent abnormalities of development identical with those resulting when the cells die naturally or without apparent cause.

The method of inflicting injuries upon one or more cells of the minute eggs studied by M. Chabry is as simple in principle as it is successful in operation, given sufficient delicacy in manipulation. The eggs are observed under the microscope in capillary tubes of glass, each egg lying without undue pressure in a separate tube of right diameter. The tube is mounted in water and covered by a cover glass so that a clear view of the egg is obtained with quite high powers. To see all sides of the egg the tube is revolved by a small crank and wheel attached to one end, turning freely in two rings of glass fixed to the microscopic slide.

The other end of the tube bears. the exceedingly sharp pointed needle that is to perforate the egg. This needle is the most difficult part of the apparatus to manufacture, being a glass rod drawn out to a point of excessive acuteness and also straight. When once made the needles are provided with a protecting piece of capillary tubule, which may either pass into the capillary containing the egg or else be joined to its end by a surrounding tube according as the egg capillary is large or very small. To move the glass dart in and out, towards and away from the egg when it has been first rightly adjusted, a small lever attached to the microscope by an ingenious and simple arrangement of spring and screw enables one to thrust the point, while observing it under the microscope, into the egg for a given distance and not further, and then to withdraw it quickly. Thus stabs are made that need affect but a single cell and any known and chosen cell.

Such is the accuracy and delicacy of this apparatus that the sea urchin's egg, only one tenth of a millimeter in diameter, was actually pierced by the finer glass needles.

To begin with this latter experiment upon the sea urchin, the needle is followed by sea water, which remains in part within the egg when the needle is withdrawn but yet gradually disappears as the egg closes in over the wound and does not afterwards exercise any evil influence upon the subsequent development of the egg. An egg entirely pierced from one side to the other subsequently formed a normal pluteus.

In the ascidian, however, the perforation of the egg or of one of its cells gives rise to its death. Within a minute after the stab is made in the protoplasm of the cell an appearance of opacity or turbidity is seen rapidly extending through the entire cell; the cell dies. Later the protoplasm coagulates and remains fixed in whatever form it was fashioned by the pressure of adjacent cells when it died. This death of the cell by stabbing is a different, much more rapid, process from the gradual death observed to occur in many eggs of abnormal origin. The part of the egg not injured develops, however, just as when the death of its fellow cell was natural or of unknown origin. In this development certain definite rearrangements of the cells take place, since they are no longer held in normal positions by the attraction of the dead cell; then cleavage continues and finally imperfect larvæ result.

Some examples of the results obtained may be given here in detail. In normal cleavage the egg divides first into a right and a left cell, these divide into anterior and posterior cells, and the four resulting cells then divide equatorially into oral and aboral cells. If, in the two-celled stage the left one be killed, the right divides into an anterior and a posterior cell as if nothing had happened to the egg, and then these two divide as usual but arrange themselves much as if the dead cell were not present, pressing together into a spheroidal mass so that the posterior upper and anterior lower cells come into contact diagonally on one side next the dead cell or median plane, just as do the other two cells on the outside or right of the egg. Thus under the influence of

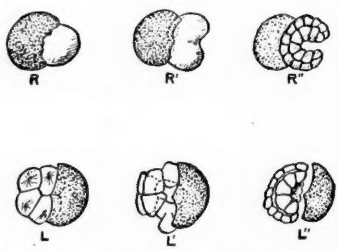
mutual attraction the four cells move so that they are arranged in a tetrahedron rather than in a square. The next change is a division of each by a plane parallel to the median plane or to the face of the dead cell.

This illustrates a marked tendency in all natural cases of death; that is, the planes that normally would be nearly meridional, turn so as to become parallel to the dead cell, parallel to a plane passing through the center of the egg.

From this eight-celled stage the development proceeds till a larva is formed, having a normal tail, three distinct germ layers, a pigmental area representing the nervous system and one papilla for attachment. Having begun to secrete its cellulose mantle it died.

Other cases were obtained showing the same results. Figure 2, R, R′, R″ shows three successive stages in the development of one of these artificial right-half embryos compared with successive stages, L, L′, L″, in the development of a left-half embryo of natural or unknown origin.

FIGURE 2



Again, when the posterior left of the normal four cells, after two planes have occurred in cleavage, is killed by the needle, an ovoid larva is obtained. In this the tail adheres along the trunk and there are three papillæ of attachment and two pigment spots. Similar monstrous forms are found when the right posterior cell is killed. When the right anterior cell is killed the tail is well formed and free from fusion with the trunk, and there are no pigment spots or imperfect ones. When the left anterior cell is killed the larva has a perfect tail, a papilla for fixation, a pigment spot and active movement. It escaped from most of the egg membranes and secreted a tunic, into which migratory cells were passing when it died.

Killing two diagonal cells of four is followed by a normal cleavage of the two remaining cells, but the experiment was

interrupted here. Killing both left cells of the four, results in the formation of larvæ which are imperfect in that there is but one papilla for attachment and one atrial invagination with one pigment spot or eye. Similar monsters result from killing both right cells, but the eye spot is absent.

When three of the four cells are killed the remaining one divides normally and forms a rounded mass of cells arranged in two germ layers, but the development does not continue further. Likewise by thrusting the needle amongst the cells of a cleaving egg, though some are killed a few may be separated and then live isolated in the sea water. Such a cell divides, with karyokinesis, into two, four, eight cells by planes at right angles, then the normal rearrangement and adjustment of the cells take place as if an entire egg were in question. The cleavage planes also occur at intervals of 20 minutes as in the entire normal egg. There results after some hours a rounded mass of twenty or so cells, larger than the original one, but there the development ceases.

In such experiments M. Chabry sees a new method of anatomical research; the history of each cell may be followed from early to late stages by killing it and observing the consequent lack in the resulting imperfect later stages. Though it is unsafe to conclude from the disappearance of an organ after the death of some particular cell at an earlier stage that that cell would have formed the organ, yet by killing all the other cells, one by one, and finding the organ present in all the resulting stages, its dependence in the normal condition upon the cell first killed becomes conclusive. In this way the author traces the eye to the right anterior cell of the first four of cleavage, the otolith to the right posterior cell; the two papillæ for attachment come from the two anterior cells while the chorda is formed by both anterior and posterior cells. Nevertheless as left-half larvæ are sometimes found with an eye, and other such cases occur, the above is upheld by the author only by aid of the supposition that the surviving cells change their habit after the death of the one, so that they now produce organs they would not normally. Thus the eyes are potentially two, though but the right one is normally produced.

Similarly the notochord is to be regarded as double or composed of two halves, one in each of the first two cells.

Nevertheless, M. Chabry regards the egg of *Ascidia aspera* as containing potentially but one adult, the organs of which seem to be localized in different parts of the egg. That this is necessarily true of other eggs he emphatically denies; the results here obtained cannot, he thinks, be extended to other untried cases. Granting that there is this localization of some organs in the ascidian egg it is evident from the author's account that all the structures are not divided by the first cleavage but rather that each cell has for the main part all that the other has, hence result active larvæ from either right or left cell, if the other be killed, larvæ which are deficient in only a few organs and by no means real half-larvæ as the author calls them.

Finally we may consider some of the experimental work that has been recently attempted upon eggs of lower animals, the echinoderms especially.

Oscar and Richard Hertwig[1] subjected eggs of *Strongylocentrotus lividus* to the action of heat, poisons and mechanical insult, to judge from the effects upon external and internal fertilization and upon cleavage as to the nature of the forces involved in the normal course of events. All these unusual agents act upon the egg so that it is unable to keep out more than one sperm, and hence is penetrated by several or many sperm, exhibiting the abnormal phenomena of polyspermy.

Weak reagents cause only a few eggs to take in two or three sperms, while strong reagents cause most all the eggs to take in four or more sperms. The substances used and the strength as well as time are given in the following tables:

WEAK REAGENTS.

Nicotine	1 drop to 1000	for 10 minutes
Strychnine	.005%	for 20 minutes
Morphine	.1 to 2%	for 2 hours

[1] O. and R. Hertwig. Ueber den Befruchtungs- und Theilungs- vorgang des theirischen Eies unter dem Einfluss ausserer Agentien. Jen. Zeit. xx, 1887, pp. 120–227, 477–510, plates 3–9.

Cocaine	.025%	for	5 minutes
Quinine	.005%	for	5 minutes
Chloral	.2%	for	12 minutes
Heat	31°C.	for	10 minutes

STRONG REAGENTS.

Nicotine	.1%	for	20 minutes
Strychnine	.01%	for	20 minutes
Morphine	.4%	for	5 hours
Cocaine	.1%	for	5 minutes
Quinine	.005%	for	1 hour
Chloral	.2%	for	3 hours
Heat	31°C.	for	45 minutes

These do not all act alike; quinine, chloral and probably cocaine and overheating temporarily stops the movement of the sperm, a diminution in size of the fertilization elevations upon the egg, postpone cleavage one-half to one and one-half hours, interrupt cleavage of nucleus, sometimes making it take retrograde steps, and interfere with formation of rays within the protoplasm of the egg.

Nicotine and strychnine, on the other hand, seem to increase the activity of the sperm and the contractility of the egg protoplasm. Morphine appears to have an intermediate action.

The authors explain the occurrence of polyspermy after the action of these agents as being due to the lack of normal sensitiveness on the part of the ovum. For normally the entrance of one sperm causes the egg to throw off a membrane which prevents the entrance of others, a membrane which is seen to be formed even upon fragments of eggs shaken loose before cleavage, yet when acted upon by these drugs the protoplasm of the egg is not sufficiently stimulated to form a membrane until several sperms have entered.

The internal fertilization, fusion of male and female nuclei, may be also retarded as much as one hour, and various unusual phenomena introduced in connection with the supernumerary sperms, without necessarily preventing the ultimate development of the oosperm.

Omitting many interesting facts bearing upon the value of male and female nucleus and cell protoplasm we pass to the effects upon the cleavage processes. The results are similar, whether the drugs act to produce polyspermy or whether they are subsequently applied after normal fertilization. Quinine or chloral acting upon an egg having its cleavage nucleus in the spindle stage transforms this spindle into a cluster of vesicles, but if the egg is now allowed to recover in sea water the nucleus divides into four with the formation of four combined spindles. The protoplasm, however, remains affected, and does not follow the subsequent division of each of the four nuclei.

The above work was supplemented soon after by a paper by Oscar Hertwig[1] describing the effects of cold upon the fertilization of the eggs of the sea urchin, and also recording the occurrence of abnormal eggs in most of the specimens found at Triest in the Spring of 1887; this result being apparently due to the unusual cold which prevented the animals collecting as usual when ripe (he finds the females discharge ova in the aquarium when a male has discharged sperm), and hence led to an overripe condition of the eggs, accompanied by subsequent abnormalities in development.

Eggs, he finds, may be kept for several hours at a temperature of 2° to 3°C. and yet recover, but they finally enter into a cold rigor. The cooling prevents the egg from forming its protective membrane and diminishes the receptive elevations upon the egg, and thus polyspermy results if the rigor does not intervene before the sperms have entered. Cooling after external fertilization may arrest the progress of the sperm, which is yet able to advance again when warmed. Cooling during the cleavage affects the nucleus so that various abnormal changes result, but the egg may still divide regularly when warmed, at least in a few cases.

One other suggestive experiment was made, namely, the treatment of sea urchins' eggs with methyl blue. This acts like a poison in causing polyspermy, yet weak solutions may be

[1]Oscar Hertwig. Experimentelle Studien am Tierischen Ei während, und nach der Befruchtung. Jen. Zeit., xxiv, 1890, pp. 268–310, plates 8–10.

used to stain the egg a violet color and yet not prevent it developing into a blastula in which the central fluid, the migratory cells and the inner ends of the outer cells are violet.

The method of inflicting mechanical injury upon sea urchin eggs used by the Hertwig's resulted in breaking them in some cases; this means of separation has been ingeniously put in action by Boveri in the attempt to solve a most important problem. Though the perusal of this paper[1] does not inspire one with as much confidence in the strength of the conclusions drawn as the reader would wish to have in evidence advanced in so important a case, yet the experiments are in themselves very suggestive and worthy of frequent repetition.

To prove that the nucleus is the bearer of inherited characters we may try to combine a nucleus with a cell and see which or if both transmit their peculiarities.

Using Hertwig's method he shook eggs of the sea urchin in test tube till many lost the nucleus; these could be fertilized and developed. In this way dwarf larvæ, about one-fourth the normal size, were reared as late as the seventh day, when the normal larvæ died also. Now the great interest of these experiments for the present question lies in the fact that the eggs belong to one species and the sperm to another.

When true bastards between normal eggs of *Echinus microtuberculatus* and sperm of *Sphærechinus granularis* are formed the resulting larva has always a middle form between the larvæ of these species, both in general proportions and in arrangement of skeletal spicules. When, however, broken fragments of the eggs of the first species are fertilized by sperm of the second we find beside some true bastards from the normal eggs and some small ones from nucleated fragments, some larvæ exactly like those reared from pure eggs and sperm of the second species alone, *Echinus microtuberculatus.*

These larvæ are regarded by Boveri as due to the fertilization of denucleated eggs of the other species by the sperm of the species they resemble.

[1]Boveri. Ein geschlechtlich erzeugter Organismus ohne mutterliche Eigenschaften. Sitzb. d. Gesellschaft f. Morphologie u. Physiologie in Munich, v, 1889, pp. 73–80.

The larvæ, when killed and examined, are found to have abnormally small nuclei, which is accounted for by the supposition that the single male nucleus of the sperm does not furnish as much material as the male and female nuclei normally do when combined.

If we accept these statements we have, indeed, most conclusive proof that in a male nucleus the sperm may transfer to a new organism the qualities of its parent.

The difficulties of the experiment lie in the unfavorable nature of the hybridization, only one in a thousand eggs being fertilized, so that of 200 actually isolated none happened to develop; then again the various abnormalities, half embryos and dwarfs that we may assume occur, make it a difficult question, we think, to decide as to the specific characters of the larvæ being due to inheritance or accidental resemblance from imperfect development.

The recent work of Driesch[1] is the last contribution in experimental embryology that has come to our notice. To determine the effect of light upon cleaving eggs he exposed the eggs of *Echinus microtuberculatus, Planorbis carinatus* and *Rana esculenta* to daylight and to complete darkness as well as to variously colored light. The result was that not only cleavage but also the formation of organs took place quite normally in time and form, entirely irrespective of the presence or character of light.

The more noticeable and unexpected part of the paper, however, deals with the question of self differentiation, as illustrated by experiments upon sea urchin eggs (as yet he has not succeeded in applying appropriate methods to eggs of frogs and Planorbis).

The eggs of the sea urchin in the two celled stage are shaken vigorously for five minutes in a test tube (some may need repeated shaking), and then such isolated cells as are present are quickly picked out and examined under the microscope in separate dishes of sea water.

[1]Hans Driesch. Entwicklungsmechanische Studien. I. Der Werth der beiden ersten Furchungs-zellen in der Echinodermenentwicklung. II. Über die Beziehung des Lichtes zur ersten Etage der theirischen Formenbildung. Zeit. f. wiss. Zool., liii, 1891, pp. 160–183, plate 7.

In this way as many as fifty cells were isolated from the two celled stages and kept separate in small vessels in which they could be examined microscopically and actually seen to develop. The separated cells develop at first, as do the uninjured cells of the frog in Roux's experiments, but the ultimate result is that each cell (of the two after the first cleavage of egg) may give rise to a complete though small larva.

This is found to be the case in both Echinus and Sphærechinus.

In the normal cleavage of Echinus, according to Selenka, there are formed two, four, eight cells, and then four at one pole bud off four small cells, while the four at the other pole divide equally. Now in the cleavage of the half egg Driesch finds two and then four cells, followed by an eight celled stage which is formed by or budded from two little cells at one pole, as opposed to an equal division of the two cells at the other pole; thus the eight celled stage is exactly the half, in form and arrangement, of the normal sixteen celled stage.

These half formations, however, become over night converted into complete blastulas having half the normal size, but apparently made up of cells of normal dimensions, so that we may infer there is half the normal number of cells. About thirty dwarf blastulas were obtained from isolated cells, and from these normally formed gastrulas, and eventually, in three cases normally formed dwarf plutei were reared. Thus it would be possible to obtain two plutei from one egg by separating the first two cells of cleavage.

The application of this to the explanation of the occurrence of twins is made easier by the actual finding of numerous abnormal stages in cleavage and gastrulation resulting in the production of twin gastrulæ or larvæ, or in some cases of combination of three-fourths and one-fourth blastulæ. As these occur so frequently in material submitted to the shaking process, which variously effect different eggs, we have reason to suppose the twins are directly due to the mechanical separation or disturbance of the material in the egg.

The heterogeneous character of the various experiments referred to in the present article and the conflicting and often

apparently meaningless results obtained by one or the other of the experimenters, while preventing an immediate incorporation of the facts of experimental physiology with those recorded by the purely observational school should not blind us to the importance of the work thus far done, both as a good beginning in a promising field and as already furnishing valuable controls for the guidance of speculations upon some of the most fundamental questions in biology.

"Toutes les expériences, toutes les mutilations qui èn fait subir à un oeuf normal, contribuent, en effet, à devoiler sa structure, et c'est certainement là une des plus belles recherches que le naturaliste puisse se proposer."

MENTAL EVOLUTION IN MAN AND THE LOWER ANIMALS.

By Alice Bodington.

(*Continued from page* 494.)

Among the lower animals the eager jumping of a dog when he is anxious to go for a walk, his growling, howling and barking to express various emotions are on a similar psychological level with the first demonstration of wishes on the part of the infant. Some of the signs and sounds expressed by domestic animals are indeterminate and some determinate, and every owner of a dog or cat can supply examples for himself.

The next step in advance taken by the infant is the utterance of articulate sounds; first various vowels and labials, *vaguely uttered without definite meaning;* then similar sounds with a definite meaning, as mamma, dada, tata, etc. These early sounds have a very extended meaning, as in Chinese the same word "bye-bye" means bed and bed-clothes, sleep and to go to sleep. But as the application of these simple syllables is usually taught to the child we are not quite at the standpoint of primitive man, who had no one to teach him. There are three different sets of opinions as to the origin of spoken words which have been named the "Pooh-pooh," the "Bow-wow" and the "Yo-heave-o" theories respectively. The first assigns the origin of language to interjectional sounds, the second attributes it to imitation of cries of animals and sounds in nature, and the third considers speech arose from the various noises made by men during concerted action. A fourth assumes language to be a heaven-sent gift and that primitive language began with abstract ideas. Applying the inductive method of reasoning and watching the development of speech in infants and the condition of language in low savages we can hope to form some idea as to how much or how

little truth there is in the above theories. We shall probably come to the conclusion that the first two theories account for a considerable number of words and that "Bow-wow" or imitative language may have given rise to many words whose imitative origin is now obscured. But watching as before the progress of the child we find that *it possesses a faculty hardly, if at all, used by its elders, of coining new words* to suit its own convenience. These words will in many cases be utterly different from the words which the child hears grown-up people apply to an object, yet the new word, having been coined by the child, will be rigidly applied to the particular object or action it was first applied to. Mr. Romanes gives several instances of children who possessed this faculty to a remarkable degree, up to the point indeed, of speaking a language of their own invention. One case is that of twin boys living in a suburb of Boston, "who, at the usual age began to talk, but strange to say, not their mother tongue. It was in vain that a little sister five years older than they tried to make them speak in ordinary English.[1] They had a language of their own, and no pains could induce them to speak anything else. Not even the usual first words 'papa,' 'mamma,' did they ever speak. In fact, though they had the usual affections, were rejoiced to see their father at his returning home each night, playing with him, etc., they would seem to have been otherwise completely taken up with each other. They passed the day playing and talking together in their own speech with all the liveliness and volubility common to children. They had regular words, a few of which the family learned to distinguish, as that for example for carriage, which was 'ni-si-boo-a,' of which the syllables were sometimes so repeated as to make a much longer word." The next case is quoted from Dr. E. Hun, who recorded it in the monthly Journal of Psychological Medicine. "The subject of this observation is a girl aged four and a half, sprightly, intelligent and in good health. It was observed she was backward in speaking, and at two years old only used the words 'papa,' 'mamma.'

[1]Paper read by Mr. Horatio Hale, published in the Proceedings of the American Association for the Advancement of Science, Vol. xxxv, 1886.

After that she began to use words of her own invention, and never employed the words used by others. Gradually she enlarged her vocabulary. She has a brother eighteen months younger than herself who has learned her language, so that they can talk freely together. He, however, seems to have adopted it only because he has more intercourse with her than with the others; he will use a proper word with his mother, and his sister's with her."

The mother has learned French, but never uses that language in conversation and the servants speak English without any peculiarities. "Some of the words and phrases have a resemblance to French, but it is certain that no person using that language has frequented the house. Of words formed by imitation of sounds the language shows hardly a trace. The mewing of the cat evidently suggested the word "mea," which signified both cat and furs. In some of the words the liking which children and some races of men have for the repetition of sounds is apparent. Thus we have 'migno-migno,' signifying water, wash, bath; 'go-go,' delicacies, as sweets or dessert; and 'waia-waia,' black, darkness, or a negro." "Gummigur," we are told, signifies all the substantials of the table, such as bread, meat, vegetables, etc., and the same word designates the cook. A number of additional instances of this strange vocabulary are given.[1] "They show," says Mr. Romanes, "that the spontaneous and arbitrary word-making which is more or less observable in all children beginning to speak may, under favorable circumstances, proceed to an astonishing degree of fulness and efficiency; that although the words thus invented are sometimes of onomatopoetic origin, as a general rule they are not so; that the words are far from being always monosyllabic;[2] that they admit of becoming sufficiently numerous and varied to constitute a not inefficient language; and that the syntax of this language presents obvious points of resemblance to the gesture language of mankind." This faculty of coining fresh words, now almost lost by adults, must once have existed as a normal state of things

[1]Mental Evolution of Man, p. 140.
[2]Where a child uses a monosyllabic word it constantly doubles the syllable.—A. B.

among human beings or it would not survive in the child.

Next to the impression made upon cells by their environment, producing the most profound and extraordinary changes of structure and functions, nothing can be more strange than the persistent heredity or atavism in cells. We can find a parallel for these two opposing forces in the centrifugal and centripetal forces which keep the planets in their orbits. What millions of ages must have elapsed since the ancestors of man diverged from the primeval worm-like hermaphrodite form! Yet not only do numerous organs survive in a more or less rudimentary condition, pointing conclusively to this origin, but there is every now and then a strange relapse to the hermaphrodite condition. The branchial arches found in every mammal with loops of blood-vessels running up to them point to an ancestry less remote, yet for all that, almost unimaginably far away in the past. The pineal gland deep hidden under the immensely developed brain of man, still tells of a third eye which could once look through an opening in the skull. And a small bone of the wrist, of no imaginable use to any mammal at present, may be a survival of an amphibian ancestor's sixth finger. So we may well believe that the faculty of fresh word-making which is being killed out in our children by the use of language ready-made in all around them is capable of a sudden revival. No doubt many of my readers will recall from their own experience the power of coining fresh words possessed by their children and the curious reduplication of syllables employed by them. We may conclude that if miocène man did not coin fresh words for himself and insist upon employing them as he chose, he was incapable of doing what his young descendant can do every day.

With regard to the theory that abstract terms were the first words used we have not only the objection that all abstract terms used by us can be traced back to material objects and actions; and the objection that no one could have understood ready-made abstract terms without a miracle; but the still stronger argument that numberless savage and semi-savage peoples cannot understand and do not use abstract terms to this day. Even so simple an abstract idea as "tail" or "tree" is beyond

the scope of their minds. Numerous instances of this fact are given by Mr. Tylor in his Primitive Culture, but I will cite some of those given by Mr. Romanes. "The Society Islanders have names for dog's tail, bird's tail, sheep's tail, etc., but no word for tail itself, *i. e.*, tail in general. The Mohicans have words to signify different kinds of cutting but no verb 'to cut;' and forms for 'I love him,' 'I love you, etc.,' but no verb 'to love;' while the Choctaw's have names for different species of oak, but no name for the genus 'oak.' Again the Australians have no name for tree or even for bird, fish, etc., and the Esquimau, although he has verbs which signify to fish seal, to fish whale, etc., has not any verb 'to fish.' 'Les langues' De Ponceau remarks 'généralisent rarement,' and he shows they have not even any verb to imply 'I will' or 'I wish,' although they have separate verbal forms for 'I wish to eat meat,' 'I wish to eat soup;' neither have they any noun substantive which signifies 'a blow,' although they have a variety which severally mean blows with as many different kinds of instruments." Similarly Mr. Crawford tells us "the Malay is very deficient in abstract words; and the usual train of ideas of the people who speak it does not lead them to make a frequent use even of those they possess. With this poverty of the abstract is united a redundancy of the concrete," and he gives many instances of the same kind as those cited from other languages. So likewise we are told 'the dialect of the Yubes is rich in nouns denoting different objects of the same genus, according to some variety of color or deficiency of members or some other peculiarity, such as 'white cow,' 'brown cow,' 'red cow;' and the Sechuano has no fewer than ten words all meaning 'horned cattle.' Cherokee presents thirteen different verbs to signify different kinds of washing without any to indicate washing itself. The Tasmanians had no words representing abstract ideas; for each variety of gum tree, wattle tree, etc., they had a name, but none for tree; neither could they express abstract qualities, such as hard, warm, soft, cold, long, short, round. A Kurd of the Yuga tribe who gave Dr. Latham a list of native words was not able

to conceive of a hand or father except so far as they were related to himself or to someone else."

In Prof. Duncan's learned Analysis of the Cherokee Language he confirms the view that savage tribes cannot express such simple abstract terms as 'hand' or 'write.' He says "Human language is not always or necessarily *expressive;* it is sometimes merely *suggestive.* In the lower grades of social life the words are generally few in number and limited in meaning. Many of them can, indeed, hardly be called words; they are more like unintelligible exclamations whose office it is not to imprint an idea or a thought upon the apprehension of the person addressed as do the words of a cultured tongue, but rather to arrest the attention and direct it to the subject in hand, leaving the desired impressions to arise in his mind as the result of his observation and reflexion. In these rudimentary tongues sentences are to be found in an embryonic state. The Cherokee is not aware that his language contains any word for hand; it is always 'äquayānē' (my hand); that is the idea of hand is always attended in expression with a conception of the person to whom it belongs. Now if we should resolve this word and assign to each idea its respective part it would stand thus: 'Äquä ayānē' (my hand), yet if these words should pass under the eyes of a Cherokee he would doubtless fail to recognize them and be apt to repudiate them as something foreign to his native vocabulary.

"While what we have said here is largely true in reference to the nouns it is much more so as to the verbs. The Cherokee never expresses the idea of an action except in connection with that of the actor, and often of the person acted on. And the adjective in expressing a quality seldom loses sight of the object to which it belongs." Speaking of the Cherokee word signifying write Prof. Duncan says: "It is to be doubted whether it was ever heard or written except in some such conglomeration of vocables as 'Wētsóyawĕlēnētóyĕ,' of which the portion 'awāl' conveys the idea of writing or drawing.[1]" In its abstract state the word would, however, be quite unintelligible and requires combination with various pronouns, tense

[1]AMERICAN NATURALIST, p. 775, September, 1889.

and mode signs before it can be understood or used by a Cherokee.

It is not contended, of course, that a savage *has* no general or abstract ideas because he *may* be incapable of expressing them. Animals have general ideas which they cannot express in language. And the savage who has no name for trees would be extremely surprised if he saw one standing on its tips with its roots in the air; one may be sure he has a general idea of a tree, with its roots in the ground and its tip towards the sky. In the same way the horses and camels at Batoura which were inordinately terrified at the first sight of a carriage and pair knew they saw something quite fresh and unaccustomed, though they had no word for it. And the horses and cattle which have grown accustomed to trains have a general idea that the rushing, screaming, roaring object is perfectly harmless, though they cannot say so. Moreover they acquire this conviction from experience.

If, then, we can accept ontogeny as a guide in understanding the primitive beginnings of human speech we may conclude that the steps consisted of screaming, varied in tone as fear or anger was to be expressed; vague labials formed by the passing of the air through the lips and gums; then labials uttered with a distinct purpose, followed in many cases by *new words invented by the child for objects.* My efforts to induce a child of my own to say "milk" resulted in the invention of the word "ningey" for that article of diet, and the attempt to teach two other children to say "nurse" resulted in the christening of that functionary as "wo" and "nan," respectively; in fact, the invention of a completely new word is as easy for a child as it is notoriously difficult for an adult human being.

One of the most extraordinary boundaries that could have been selected as the "Rubicon of mind" has been fixed in the possession of a verb which once expressing such simple concrete ideas as "to stand," "to breathe," has acquired the abstract signification "to be." "If a brute could think 'is' brute and man would be brothers." Here is the point where instinct ends and reason begins. It is not possible to produce

a brute which can *say* "is" (whatever it may think), for the simple reason that brutes do not employ articulate language. But languages belonging to the highest ancient civilizations, as "well as the languages of savages, have also no word for "is." Taking one instance only, the Coptic, it has been observed[1] "what are called the auxiliary and substantive verbs in Coptic are still more remote from all essential verbal character than the so-called verbal roots. On examination they will almost always be found to be articles, pronouns, particles or abstract nouns, and to derive their verbal functions entirely from their accessories or from what they imply. In fact, any one who examines a good Coptic grammar or dictionary will find there is nothing formally corresponding with our 'am,' 'art,' 'is,' 'was.' The Egyptians had, however, at least half a dozen methods of rendering the Greek verb substantive when they desired to do so." Instead of saying 'Petrus est,' 'Maria est,' 'Homines sunt,' it is quite sufficient and perfectly intelligible to say 'Petrus hic,' 'Maria hoce,' 'Homines hi." The above forms, according to Champollion and other investigators of ancient hieroglyphics, occur in the oldest known monumental inscriptions, showing plainly that the ideas of the ancient Egyptians as to the method of expressing the category 'to be' did not accord with those of some modern grammarians. . . . . Every Semitic scholar knows that personal pronouns are employed to represent the verb substantive in all the known dialects, exactly as in Coptic, but with less variety of modification. . . . . The phrase 'Ye are the salt of the earth' is in the Syriac version 'You they (*i. e.*, the persons constituting) the salt of the earth.' Nor is this employment of the personal pronoun confined to the dialects above specified, it being equally found in Basque, in Gala, in Turco-Turanian and various American languages. . . . .

"Malayan, Japanese and Malagassy grammarians talk of words signifying to be; but an attentive comparison of the elements which they profess to give as such, shows clearly that they are no verbs at all but simply pronouns or indeclinable particles commonly indicating the time, place or manner of

[1]Garrett on the Nature and Analysis of the Verb. Proc. Philo. Soc., Vol. iii.

the specified action or relation. . . . A verb substantive such as is commonly conceived, vivifying all connected speech and binding together the terms of every logical proposition, is much upon a footing with the phlogiston of the chemists of the last generation—*vox et prœterea nihil*. . . . If a given subject be 'I,' 'thou,' 'he,' 'this,', 'that,' 'one;' if it be 'here,' 'there,' 'yonder,' 'thus,' 'in,' 'on,' 'at,' 'by;' if it be 'sits,' 'stands,' 'remains,' or 'appears' we need no ghost to tell us that it *is*, nor any grammarian or metaphysician to proclaim that recondite fact in formal terms."

It seems then that no more unfortunate point could have been chosen than the use of the verb "to be" as constituting the Rubicon of mind; it has only served to accumulate proofs that there is no Rubicon in the sense of a distinct barrier between the minds of men and animals, and that if a dividing line be arbitrarily drawn it must be not between man and brute, but between the lower animals, young children and savages on the one hand and civilized man capable of true abstract ideas on the other.

A young child has made a distinct step in advance when he speaks of himself in the first person. But many tribes of savages have never yet risen to this consciousness of the "ego;" but for such an expression as "I will eat the rice" we have recourse to the form "The eating-of-me-the-rice."[1]

If a child exclaims "black man" at the sight of a negro he expresses the same idea that we do in saying "that man is black;" if he says "dit ki" (sister is crying), "dit dow ga" (sister is down on the grass), "dat a big bow-wow" (that is a large dog),[2] he is implicitly predicating certain facts and forming certain judgments precisely as if he formally used the copula. "The child perceives a certain fact and states the perception in words *in order to communicate information of the facts to other minds*, just as an animal under similar circumstances will employ a gesture or vocal sign." A cat cannot express in words the ideas "my kitten is shut in a drawer;

[1]Malayan and Polynesian Languages. Mental Evolution of Man, p. 313.

[2]See p. 203, Mental Evolution of Man.

you can take it out if you come;" but she can eloquently express her meaning by vocal signs and gestures.

Another clue to the evolution of language may be found in the sign language of educated deaf-mutes and its grammatical construction. The deaf-mute does not make the statement "bring a black hat," but "hat black bring;" not "I am hungry, give me bread," but "hungry, me bread give." The Abbé Sicard says: "A pupil to whom I put this question, 'who made God?' replied 'God made nothing.' I was accustomed to this inversion usual amongst the deaf and dumb, and I went on to ask him 'who made the shoe?' and he answered, 'the shoe made the shoemaker.' Laura Bridgman would spell on her fingers 'that door,' 'give book,' which she had been taught, but when she made sentences for herself she reverted to the usual deaf-and-dumb system, 'Laura bread give,' 'water drink Laura,' to express her wish to eat or drink."

Mr. Tylor says: "The gesture language has no grammar properly so-called; it knows of no inflections of any kind more than the Chinese. The same sign stands for 'walk,' 'walkest,' 'walking,' 'walked,' 'walker.' Adjectives and verbs are not readily distinguished by the deaf-and-dumb. 'Horse, 'black,' 'handsome,' 'trot,' 'canter,' would be the rough translation of the signs by which a deaf-mute would state that a handsome, black horse trots and canters. The deaf-mute strings together the signs of the various ideas he wishes to connect, in what appears to be the natural order in which they follow one another in his mind, *for it is the same among the mutes in different countries,* and is wholly independent of the syntax which may happen to belong to the language of their speaking friends.

With regard to the sign language of Indians Mr. Tylor says: "There is no doubt that the Indian pantomine is not merely capable of expressing a few simple notions, but that to the uncultured savage, with his few and material ideas, it is a very fair substitute for his scanty vocabulary." Forty-three examples of this gesture language are given, collected by Mr. Pehoff, as occurring between Indians of different tribes. Colo-

nel Mallery in his Dictionary of Indian Signs observes: "The sign language of the Indians, and the gesture system of deaf-mutes, and of all peoples, constitute together one language—the gesture speech of mankind—of which each system is a dialect."

In Italy the power of expression by pantomine is particularly strongly developed, and whole plays are carried out through the use of gestures alone, and are thoroughly enjoyed by the people. Even in England, where gestures are less used than in any other country, one is astonished at the number of ideas which we can, and do, express by gestures. Knowing the strong influence of atavism, it is a legitimate deduction from the world-wide prevalence of gesture language that gestures formed an important part of the original means of communication between human beings, and if we are to judge from ontogeny, preceded the imitation of sounds in nature and the arbitrary invention of words, and developed *pari parsu* with the original howls and shrieks of primitive man. Tribes still exist whose words are unintelligible without the aid of gesture, and who are unable to carry on a conversation in the dark.

Researches into the mental faculties of civilized children and uncivilized men, as well as into the mental faculties of the highest animals, such as the elephant, the monkey and the dog, show, as was said at the beginning of this article, a difference of degree but not of kind. Immense is the distance between the mind of a Shakespeare or a Newton and the mind of a Hottentot. But the distance is also immense between the green scum, the one-celled alga of our ponds and ditches and the lordly oak; yet each belongs to the vegetable kingdom, and there is no break in the innumerable forms which fill up the wide space between the pond scum and the oak.

With regard to the theory that language is a divine gift from the very beginning bestowed upon man and denied to the lower animals, some light is thrown by the condition of what may be called 'relapsed man;' those cases where children have either been reared by and with wild animals or

have run into the woods when young and managed to survive.

An instance recently occurred on Mount Pindus, in Thessaly. The warden of the King's forest on Mount Pindus was strolling up to a shepherd's hut whilst on a shooting expedition, to procure a drink of milk. He heard a rustling in the bushes, and was raising his gun when the shepherd called out to him not to shoot. He saw a naked creature in the form of a man running in front of him, sometimes on its feet, more often on all fours. It reached the hut and began eagerly sucking up the buttermilk out of a trough into which cheeses had been pressed. The shepherds said the child was a Wallachian by birth. His father died, and his mother, distributing her children amongst her neighbors, went back to her own country. This boy had escaped into the woods and had kept himself alive there for four years. In the summer he drank buttermilk daily and 'lived well;' in the winter he took shelter in the caves and eat herbs and roots. The warden, pitying the child, bade the shepherds catch and bind him with a rope and then took him to his home at Trikala. Here he fed and clothed his little Orson, and placed him with a person who endeavored to teach him to talk, or kept the child when possible under his own charge. But the boy has *never learned to speak a word,* though he imitates the voices of many wild creatures.[1] The same inability to speak has been shown in the cases of other 'wild' children found in India, collected by Colonel Sleeman, the able officer who helped to suppress thuggism. In a district near the Goomtee River in the Province of Oude, wolves are never killed by the villagers from a fear of the ill-luck which their death might bring upon the village, and wolves consequently abound. A native trooper saw a large she-wolf leave her den, followed by three whelps and a little boy, all on their way to the river to drink. When chased by the trooper they all escaped to their den, the boy running on all-fours as fast as the young wolves. The whole party was dug out; the wolves were dug out and bolted; the boy was caught, bound with a rope, and

[1] See Spectator, Jan. 9th, 1892.

after four days sent to an English officer, Captain Nicholetts. He was kindly treated, but he never learned to speak; he would fly at children and try to bite them, and ran to eat his food on all-fours. But he was friendly with a pariah dog, and would let him share his food. He would suck up a whole pitcher of milk. He never laughed or smiled, destroyed all his clothes, and in two years and a half ended his short life of piteous degradation, speaking once or twice as he lay dying, the words for water and aching head. Another child, caught in the same neighborhood, was even more savage, and would only eat raw flesh, on which he put his hands as a dog puts its fore-feet. His knees and knuckles were quite hard with running on all-fours. He was quite untamable, and at last lived in the village street with the pariah dogs, going every night into the jungle. A third boy, caught at Hasanpur, exhibited the same characteristics, his favorite playmates being the jungle wolves, which would caper round him and lick him. In all these cases the characteristics of relapsed man are the same; he walks and runs well on all-fours, cannot be taught to speak, lives on raw food, and drinks by suction, as a horse or cow drinks.

Now if language be a God-given endowment exempt from the usual laws of evolution, a wild boy with uninjured brain should be able to learn to speak readily; indeed, he should be able to evolve some form of speech by himself. If, however, articulate speech is the result of long ages of evolution from speechless ancestors we can understand that the centre for articulate speech in the human brain requires stimulating and cultivating from early infancy; and if not so stimulated and cultivated will fail to exercise a faculty acquired *comparatively* late in the evolution of the species. With regard to other characteristics, every little child goes on all-fours, and not like any other animals, on the toes or soles of the feet, but on the knees. And every infant at first tries to "drink like a calf," putting its mouth *into* a cup to suck up the milk, and only slowly learning to drink from the edge.

It seems to me that the weight of evidence afforded by facts is in favor of the hypothesis that the human mind has fol-

lowed the laws of evolution like everything else we know of in the universe; and that the apparent abyss between the intellect of man and that of the lower animals lies, as I have said before, in the nature of the organ which has been specially evolved in *Homo sapiens.*

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MINERALOGY AND PETROGRAPHY.[1]

The Basalt of Stempel.—Bauer's[2] description of the basalt of Stempel, near Marburg, and its concretions and inclusions is one of the most excellent pieces of petrographical work that has appeared in a long time. A favorable opportunity has enabled the author to secure a splendid suite of specimens of this rock so noted for its beautiful zeolites. It consists of the usual constituents of basalt, viz.: plagioclase, augite and olivine in a groundmass of augite and feldspar microlites in a base of glass. The plagioclase is andesine without peculiar characteristics. The augite is also without special features except that it is frequently zonally developed, with a dark-green kernel and brown-colored coats, in which the extinction decreases from 48° to 36°. The olivine is so well bounded by crystal planes that the relations of the shapes of the cross-sections to the crystallographic axes have been well worked out. Twins parallel to $P\breve{\infty}$ are not uncommon. The liquid inclusions, upon careful study, are found to differ from those of the olivine of the concretions (Knollen), and the glass inclusions are learned to have a different composition from the glass forming the groundmass of the rock. One of the most interesting features of the rock is the occurrence of amygdaloidal cavities, coated within by a layer of glass, whose limits are sharply defined. Sometimes a partition of this glass divides a cavity into two, and occasionally several concentric partitions give rise to a series of chambers that are strikingly like the chambers in Idding's lithophysae. The olivine bombs included in the rock consist largely of bronzite and chrome-diopside grains cemented by olivine substance. The bronzite is present in two varieties, one an almost opaque greenish-brown kind, and the other a transparent olive-green variety. Picotite is also present quite abundantly in grains and aggregates of grains in most of the bombs. The effect of the action of the rock magma upon its inclusions is seen in the granulation of the pyroxenes, and the effect of the material of the bombs upon the magma is shown in the presence of microlites of hypersthene in the veins of the rock that ramify the bombs. Since the minerals of the bombs contain characteristic inclusions not common to lherzolitic rocks, and since, moreover, the olivine and bronzite are sometimes found in forms never seen in lherzolite, the author

[1]Edited by Dr. W. S. Bayley, Colby University, Waterville, Me.
[2]Neues Jahrb. f. Min., etc., 1891, ii, p. 156.

concludes that these bodies are not inclusions torn from a deep-seated basic rock as is sometimes thought, but that they are concretions of the basic minerals of the basalt, formed during the intratellurial period of its magma's history. Another interesting feature of the Stempel occurrence is the abundance and variety of true inclusions found therein. These are limestone, quartz, feldspar and amphibolite fragments and others torn from a cordierite rock. The limestone has produced but little effect upon the surrounding rock other than rendering its texture coarser by increasing the size of its feldspathic constituents. The limestone itself has suffered little change. The quartz fragments are all surrounded by rims of green augite crystals, and in their interior they are filled with swarms of cavities either empty or filled with liquid. Sandstone inclusions now consist of grains of quartz, cemented by a glass that has originated in the fusion of the cement of the original rock. This glass sometimes contains trichites and magnetite grains, when it is colorless; sometimes it is devoid of them and is colored brown. The glass cement also frequently contains drops of glass that differ from the enclosing material in that it dissolves readily in hydrochloric acid, while the latter is unaffected by this reagent. The included substance is regarded as the pure glass produced by the solution of the cement of the sandstone, while the insoluble variety is that to which silica has been added by the corrosion of the quartz grains. The finer grained sandstones have yielded basalt-jasper. In their glassy constituent are numerous crystals of apatite that are similar in most of their properties with the nepheline and cordierite crystals observed by Zirkel in some of the basalt-jaspers described by him. The orthoclase inclusions are penetrated by tiny veins of glass. Both the feldspar and the glass contain small violet octahedra of some spinel and blue pleochroic needles of glaucophane, while tridymite plates occur in the latter substance. An aggregate of orthoclase and plagioclase contains flecks of green glass between the grains that is thought to be fused mica, while the feldspar is filled with sillimanite needles. The other inclusions present features that are worthy of notice, but they cannot be described in the present place. The article will well repay the reader for its perusal.

The Crystalline Rocks of Tammela, Finland.—The archean rocks in the vicinity of Tammela, in the South-western part of Finland, are crystalline schists, granites, gabbros, porphyrite and vitrophyres. A gray granite, Sederholm[1] thinks, is closely related to the

[1]Min. u. Petrog. Mitth., xii, p. 97.

gabbros and diorites of the region, which appear as though basic separations from the same magma as that yielding the granite. The most abundant rock is a muscovite granite. Next in importance is a uralite-porphyrite, whose uralitic phenocrysts are complete pseudomorphs of augite. All the constituents of the rock show much alteration. The plagioclase is changed to epidote and zoisite, and between the secondary products of this mineral are newly formed plagioclase and hornblende, and in addition there are frequently accumulations of biotite, whose form leads to the supposition that they are pseudomorphs after olivine. In its original condition this rock was probably a basalt. A plagioclase-porphyrite, an amygdaloid and glassy rocks with the composition of an acid basalt also occur in the region. Tufas accompanied the outflow of basalt, but in this as in the other rocks described the character of the original substance has been greatly obscured by alteration. In discussing the cause of the chemical changes that have been effected, the author ascribes the most powerful action to water in connection with pressure. Many of the rocks show evidences of dynamo-metamorphism. A schistosity has been superinduced in nearly all of the types, but the crushing and breaking of grains that are such striking phenomena in most instances of this kind, are here absent. The pressure exerted its influence principally in increasing the solvent power of the water. Very little change in the chemical composition of the rocks has resulted from the alteration, in spite of the fact that their mineralogical composition has been totally changed.

Petrographical Notes.—The breccias and porphyries of Pilot Knob, Mo., have repeatedly been stated to be metamorphised fragmentals. Haworth[1] has examined their relations to other rocks and has carefully studied their thin sections with the result that they are pronounced by him true eruptives, the latter, quartz-porphyries, exhibiting flowage structure, and other evidences of having once been liquid, and the former, porphyry breccias, with fragments of porphyry cemented by a groundmass that was once a fluid volcanic lava.——Cordierite-bearing chiastolite schists are briefly mentioned by Klemm[2] as forming part of the contact belt of the Lausitz granite at Dubring, and dykes of hornblende-porphyrite as cutting the granite at this place and at Schmerlitz, in Saxony.——In a brief communication Kemp[3] speaks of the existence of several dykes of a very much altered

[1]Bull. No. 5, Geol. Surv. of Mo., p. 5.

[2]Zeits. d. d. Geol. Ges., xliii, 1891, p. 526.

[3]Amer. Jour. Sci., Nov., 1891, p. 410.

peridotite in the Portage sandstones near Ithaca, N. Y.——In a hornblende-andesite inclusion in the Capucin trachyte Lacroix[1] finds one cavity containing magnetite, biotite, fayalite and hypersthene—a different association of minerals from that in any other cavity. The most interesting of these minerals is the fayalite, which occurs in tiny crystals with a golden yellow color, due to a ferruginous pigment.

Mineralogical News.—A series of new analyses of *amarantite* from the Mina de la Campania, near Sierra Corda, Chile, give: $SO_3 = 35.46$; $Fe_2O_3 = 37.46$; $K_2O = .11$; $Na_2O = .59$; $H_2O = 28.29$, corresponding to $Fe_2\,S_2O_9 + 7H_2O$. The mineral has a specific gravity of 2.286, and at 110° it loses three molecules of water. Its axial ratio as determined by Penfield[2] is $a : b : c = .7692 : 1 : .5738$ with $\alpha = 95° \; 38' \; 16''$; $\beta = 90° \; 23' \; 42''$, $\gamma = 97° \; 13' \; 4''$, and 2Ena = 63° 3′. In sections parallel to the trachy-pinacoid the extinction is 16°–17° in acute β. *Sideronatrite* from the same place occurs in fine orange or straw-yellow fibres, with orthorhombic symmetry (not monoclinic as Raimondi asserts). Its density is 2.355. A mean of several analyses yielded:

$$\begin{matrix} SO_3 & Fe_2O_3 & Na_2O & H_2O \\ 44.22 & 21.77 & 16.39 & 17.07 \end{matrix} = 2Na_2\,SO_4\,Fe_2\,S_2O_9 + 7H_2O.$$

The mineral suffers a loss of four molecules of water at 110°. Associated with sideronatrite are little white masses composed of a substance with hexagonal optical properties. It is positive with $\omega = 1.558$, $\epsilon = 1.613$ for yellow light. Its density = 2.547–2.578, and its composition is: $H_2O = 11.89$; $SO_3 = 51.30$; $Fe_2O_3 = 17.30$: $Na_2O = 19.63$; $K_2O =$ ca. .16, corresponding to $3Na_2\,SO_4$, $Fe_2(SO_4)_3 + 6H_2O$. With these analyses are also given those of a *picropharmacolite* from Joplin, Mo., of *pitticite* from the Clarissa Mine, Utah, of *gibbsite* from Chester Co., Pa., and of *atacamite* from Chile. The analysis of the first mentioned mineral leads to the formula $(H_2\,Ca\,Mg)_3\,As_2\,O_8 + 6H_2O$. The pitticite gave: $H_2O = 17.64$; $As_2O_5 = 39.65$; $Fe_2O_3 = 33.89 = 4Fe_2(As\,O_4)_2 .\; Fe_2(OH)_6 + 20H_2O$. The mineral is not a mixture of the sulphate and arsenate of iron as is the German variety. No definite conclusion was reached as to the composition of the gibbsite other than that it is a hydrous aluminum phosphate.——Though *columbite* has been known to exist in the Black

[1]Bull. Soc. Franc., d. Min., xiv, p. 10.

[2]Zeits. f. Kryst., xviii, p. 585.

Hills in Dakota for some six years past, the first accurate account of its occurrence and of its composition has but just been communicated by Mr. Headden.[1] The mineral together with *tantalite* is often present in the stream tin of the hills. It is also found imbedded in beryl at the Etta Mine and associated with other minerals at the various other mines in the district. Fourteen analyses of crystals obtained from the different localities are given. Some of these correspond with the formula $3R\ Cb_2O_6 + 2R\ Ta_2O_6$, with $R = Fe_{\frac{1}{2}}\ Mn_{\frac{1}{2}}$. As the density of the mineral becomes greater the proportion of tantalum to columbium increases, passing from 1 : 6 to 1 : 1¼ ; thus indicating that columbite and tantalite are isomorphous substances. Analyses follow: I. Turkey Creek, Col.; II. Yolo Mine, S. Dak.; III. Tantalite, associated with stream tin at the Grizzly Bear Gulch, S. Dak.; IV. Manganiferous columbite, from Advance Claim, 1½ miles S. of Etta Mine.

	Cb_2O_5	Ta_2O_5	SnO_2	WO_3	FeO	MnO	CaO	Sp. Gr.
I.	73.45	2.74	.21	1.14	11.32	9.70	.61	5.383
II.	24.40	57.60	.41		14.46	2.55	.73	6.592
III.	3.57	82.23	.32		12.67	1.33		8.200
IV.	47.22	34.27	.32		1.89	16.25		6.170

Mr. Headden's results are interesting as indicating the widespread occurrence of these two rare minerals in the Black Hills region, and his paper is valuable for the great number of analyses contained in it. ——Laspeyres[2] has reexamined the *saynite* (of V. Kobell) from Grube Grüneau, in Kirchen on the Sieg, in Germany, where the mineral occurs in crystals. He finds it to be a mixture of polydymite with other sulphides, as he declared it to be some time since. *Ullmanite* crystals from Siegen, in the same neighborhood, are described as consisting of cubes with striations parallel to the pyritoid edge, or of cubes, dodecahedrons and octahedrons combined with more complicated forms, among which are many parallel hemihedral ones. Its crystallization thus corresponds with that of the Sardinian Ullmanite described by Klein.[3] A rare chance was also afforded Laspeyres for the study of the crystallization of *wolfsbergite*, from Wolfsberg, in the Harz. The new crystals obtained by him are tabular parallel to oP,

[1]Amer. Jour. Sci., Feb., 1891, p. 89.

[2]Zeits. f. Kryst, xix, 1891, p. 417.

[3]Neus. Jahrb. f. Min. etc., 1883, i, p. 180 and 1887, ii, p. 169.

and have the macro-zone more highly developed than the brachy-zone. They show clearly that Groth is correct in regarding the mineral as isomorphous with amplectite, scleroclase and zincenite. The axial ratio, calculated from pyramidal faces that gave good reflections, is $a : b : c = .5283 : 1 : .6234$.——The little-known members of the *mesotype* group on the Puy-de-Dôm have recently been described by Gonnard[1] in some detail as regards localities. An analysis of the natrolite from the Puy-de-Maman yielded: $SiO_2 = 48.03$; $Al_2O_3 = 26.68$; $Na_2O = 15.61$; $H_2O = 9.62$; and that of the Tour de Gevillat gave: $SiO_2 = 47.88$; $Al_2O_3 = 26.12$; $Na_2O = 15.63$; $CaO = .45$; $H_2O = 9.80$.——The same author[2] has made a crystallographic study of the *barites* of the Puy-de-Dôm. All crystals of this substance are beautifully modified but none show new forms. A peculiarly habited *aragonite*[3] from the Neussargnes Tunnel, Cantal, contains the new forms $\frac{13}{3}P\breve{\infty}$ and $\frac{3}{2}P$.——The investigation of the nature of the nitrogen found in *uraninite*, promised some time ago, has been continued by Hillebrand[4] without, however, very great success. The most careful analyses of specimens from Glastonbury, Ct., and from Arendal, Norway, yield respectively:

UO_3	UO_2	ThO_2 etc.	PbO	CaO	H_2O	N	Fe_2O_3	SiO_2	Insol.	Sp. Gr.
23.03	59.93	11.10	3.08	.11	.43	2.41	.29	.16	.89	9.622
26.80	44.18	13.87	10.95	.61	undet.	1.24	.24	.50	1.19	

The principal result of the analyses is to the effect that all uraninite contains more or less nitrogen, sometimes amounting to as much as $2\frac{1}{2}\%$. The condition in which the element exists is unknown, but it is probably different from any hitherto observed in the mineral kingdom. Another result indicated is that the formulas that have been accepted as expressing the composition of the mineral do not do so. Specimens from many of the classical localities have been analyzed, and in nearly every case errors have been detected in the original analyses. The author concludes that while uraninite in general contains the same constituents, it varies widely in composition, and its physical characteristics are often as distinct as are the chemical differences.——The *keramohalite* from Pico de Teyde, in the Canary Isles, is in little imperfectly developed crystals imbedded in a yellowish white hygroscopic

[1]Bull. Soc. Franç. d. Min., 1891, xiv, p. 165.

[2]Ib., xiv, p. 174.

[3]Ib., xiv, p. 183.

[4]Bull. U. S. Geol. Survey, No. 78, p. 43.

granular mass, in the neighborhood of solfataras. The soluble substance extracted from this mass by Hof[1] gave:

SO_3	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	H_2O
38.62	13.96	.94	.66	.22	.04	2.37	42.01

The form of the crystals as determined by Becke[2] is tabular parallel to $\infty P\breve{\infty}$. They have a weak negative double refraction. The axis of mean elasticity is inclined 48° to $\infty P\overline{\infty}$, and that of the least elasticity 13° to $+P\overline{\infty}$. The crystallization is monoclinic with $a : b : c = 1 : ? : .825$ $\beta = 97° 34'$.——In the druses of a massive *garnet* used as a flux in the copper smelters at Kedobek, Caucasia, are found crystals of garnet that rival in beauty the famous Tyrol varieties. They are bounded by the forms 2O2, ∞O and occasionally $3O\frac{3}{2}$, and all the faces are brilliant. Their color is wine to honey-yellow and their composition[3] is represented by:

SiO_2	CaO	Al_2O_3	Fe_3O_3	Loss	
39.12	35.84	22.73	1.76	.15	$=Ca_3\ Al_2(SiO_4)_3$.

——According to Branner[4] inexhaustible beds of *beauxite* occur near Little Rock and Benton, Ark., that are supposed to be genetically related in some way with eruptive granites. The material is pisolitic in structure. The composition of one variety as shown by a partial analysis is:

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	Loss
55.64	10.38	1.95	3.50	27.62

——The handsome *calcite*[5] twins from Guanajuato, Mexico, that have been known for some time, are usually the scalenohedron R^3, twinned parallel to $-\frac{1}{2}R$. Corresponding pairs of faces on each individual are so developed that their combination has a monoclinic habit, resembling strongly the swallow-tailed twins of gypsum. The forms recognized in the crystals are mentioned in the paper and six figures accompany it.

[1]Min. u. Petrog., Mitth. xii, p. 39.

[2]Ib., p. 45.

[3]Müller: Neues. Jahrb. f. Min., etc., 1891, i, p. 272.

[4]Amer. Geologist, vii, 1891, p. 181.

[5]Pirsson: Amer. Jour. Sci., Jan., 1891, p. 61.

——Frenzel[1] has made a new analysis of *gordaite* and has found it to be identical with ferronatrite, while Arzruni has examined its crystals and declares them to be rhombohedral with $a : c = 1 : 55278$.——C. Schneider[2] gives good analyses of six basaltic hornblendes, all of which contain over 4% of TiO_2.

[1]Zeits. f. Kryst., xviii, p. 595.

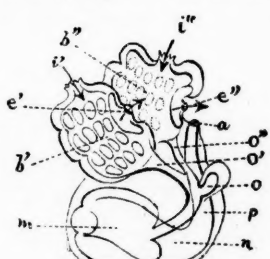
[2]Zeits. f. Kryst., xviii, p. 579.

ZOOLOGY.

Temperature and Color in Lepidoptera.—At the meeting, March 24, 1892, of the South London Entomological and Natural History Society, Mr. F. Merrifield exhibited examples of *Selenia illustraria, S. illunaria, S. lunaria, Vanessa urticæ, Platypteryx falcataria, Chelonia caia, Bombyx quercus* and var. *callunæ*, to illustrate the effects of temperature on these species. He prefaced his remarks by referring to the experiments of Weismann and Edwards which were made on seasonally dimorphic species, and said that his results were consistent with those of these gentlemen; but he went further than they did, and he found that by subjecting the pupæ to certain temperatures he invariably, in the majority of specimens, obtained certain results, a lower temperature generally producing darker and more intense colors than higher temperatures. In *illustraria*, a brood divided into two portions, and one placed at a temperature of about 80°, produced normal specimens, while the other portion, placed at 50° or 60° were strikingly darker in color. The same results, but in less degree, were obtained with other forms. In *V. urticæ* some of the examples closely approached var. *polaris*, the specimens exposed to the lower temperature being generally darker and the blue crescents more intense in color. In conclusion Mr. Merrifield said that a temperature of 47° seemed to stunt the size and produced a large proportion of cripples, and higher temperatures than this seemed more conducive to health and vigor. It had been suggested that the results he obtained were attributed to the unhealthy conditions to which the pupæ were exposed, but this was not at all a correct explanation; in the 172 specmens he exhibited 150 were not cripples. Extreme temperatures produced crippling, but moderate temperatures were quite sufficient to account for the extreme difference in coloring. Mr. Fenn said he had since 1859 paid great attention to the earlier stages of Lepidoptera, and he assumed that variation was either natural or artificial. Natural variation might again be divided into three nearly equal causes: heredity, moisture and natural selection. In artificial selection the causes might generally be said to be abnormal or diseased. By disease he meant a general weakening of the constitution by unnatural influences; the least deviation from natural conditions might produce variation. Mr. Fenn had had considerable experience in breeding *E. autumnaria*, one of the species relied on, and in the series he exhibited

there were many paler and many darker than any shown by Mr. Merrifield; and the larvæ and pupæ had been kept under usual conditions, and the greater proportion of them followed the parent forms. In conclusion he said that such variation as was shown by Mr. Merrifield was impossible in nature except as a result of disease. Several gentlemen continued the discussion, Mr. Tutt following Mr. Fenn in attributing the variation to disease, and saying that to a large extent it was caused by preventing the proper development and formation of the coloring pigment. He thought the action of temperature indirect, producing variation by interfering with the normal development. Mr. Merrifield agreed with many of Mr. Fenn's observations and thought most of them consistent with his own experiments. In any case he thought that in the species studied by him the temperature was so moderate as not to interfere with health, and yet it produced, with great uniformity, considerable differences in color. In some other species no considerable changes were produced unless the temperature was so extreme as to produce crippling or imperfect development.—(Entom. Monthly Magazine.)

A Curious Compound Ascidian.—In a current number of a Japanese zoological journal,[1] Mr. A. Oka, now of Freiburg, i | Br., Germany, describes an interesting phenomenon in the life of a compound Ascidian, *Diplosoma*, which he collected some years ago at Misaki, Japan. As an examination of the accompanying diagram will show, the œsophagus of each individual Ascidian is divided into two branches (o′ and o″), each branch terminating in one branchial basket (b′ and b″) respectively. The branchial basket indicated by the dotted line (b″) is old, while the other basket (b′) is young and functional. On the other side of the œsophagus is represented a young bud (o) which, when fully unfolded, becomes a functional branchial



apparatus, and takes the place of (b′); the oldest basket (b″) having disappeared by that time. Various intermediate stages indicating this state of transition have been observed. In such forms the œsophageal end of the alimentary canal shows division into three branches. The

[1] *The Zoological Magazine* (Japanese), vol. iv, no. 42, pp. 144–146, April 15, 1892. Tokio, Japan.

anus (a) opens in *Diplosoma*, as in *Appendicularia*, independently by itself; hence, the anus does not share with the branchial basket the phenomenon of occasional regeneration, but persists throughout life. In one individual, then, such as is shown in the accompanying diagram, there exist five openings, *viz.*, the old incurrent pore (i″), the old excurrent pore (e″), the young incurrent pore (i′), the young excurrent pore (e′) and the permanent anus (a).

This regeneration of a complete organ, not as a result of artificial mutilation of the organism, nor as the result of the removal of any part, but as a result of a normal physiological process is very remarkable. Mr. Oka thinks it similar to certain pheuomena common in the vegetable kingdom.—(Translated and abstracted by Dr. Watase, Clark University.)

The Development of the Teeth of Man.—Dr. Carl Röse has studied the development of human teeth and comes to the following conclusions.[1] The first trace of the primary dental ridge appears simultaneously (34–40 days) in both jaws. It is in section a semicircular ingrowth of not yet differentiated cells of the epithelium of the jaw. It appears at the same time with Meckel's cartilage. At about 48 days (17 mm) the primary dental ridge splits into two ridges lying at right angles to each other. Of these the one going vertically into the jaw is the labial groove ridge, the other, going horizontally into the jaw, is the true dental ridge. The deepest layer of the epithelium is of high cylindrical cells. The labial groove ridge continues to grow deeper while its upper layer becomes resorbed, thus giving rise to the furrow between the lip and the jaw, the process beginning at the middle and extending each way. The slight dental groove which runs along the line of the union of jaw epithelium and dental ridge is at first on the outer surface of the jaw and gradually wanders in a spiral line over the jaw to the posterior surface, the middle advancing more rapidly than the sides.

The dental ridge which at first was horizontal changes its position as a result of the growth of the milk teeth, and becomes more and more vertical. Its free edges become produced into undulatory outgrowths, ten in number, which become spherical and form the first anlagen of the milk dentition. At the tenth week (embryo of 32 mm length) there begins simultaneously, or in quick succession, the pushing in of the papillæ into these outgrowths, *and these connective tissue*

[1]Arch. f. mikr. Anat. xxxviii, 447, 1891.

papillæ do not push into the deepest but into the lateral portion. In this way the dental ridge can continue its growth behind the milk-teeth unhindered by the process of separation of these teeth, which begins in the fourteenth week. At the same time the ridge shows irregular outgrowths and three weeks later these have become more evident, and in the region of the incisors a partial fenestration of the ridge is begun.

At the twenty-fourth week the dental ridge, in the region of the anterior teeth, has become converted into a sieve-like plate with irregular projections; in the molar region it is as yet smooth and unbroken and its under margin retains the thickened and undulating character. In front of and mesial to these thickenings are the milk teeth, and from the side of these milk teeth the papillæ of the permanent teeth (the incisors first) encroach upon the thickened margins of the dental ridge. The dental ridge grows behind the second milk molar in the fourteenth week and at the seventeenth its end is thickened, and from this thickening is developed the first permanent molar.

At the time of birth the ridge extends behind the first molar as a short thickened plate which at the sixth month has extended farther backward and has become thickened for the second molar which is formed as before. In the child of three and a quarter years the condition behind the second molar is like that in the child at birth, behind the first molar. The wisdom tooth arises about the fifth year by a lateral ingrowth like that of the other molars. Owing to the extraordinary adaptability of the dental ridge there is a possibility of a fourth molar behind the wisdom tooth and also of a third dentition in the anterior portion of the jaws.

Odontogenesis in the Ungulates.—Julius Laecker, of the Veterinär Institut of Dorpat, has just completed a most interesting series of studies upon Odontogenesis in the Ungulates. He undertook their investigation with the purpose of determining how far the embryological development of the crowns of the molar teeth repeats the palæontological development, and especially to test the theory of bunodont origin advocated by Cope and Gaudry as opposed to the earlier Rütimeyer-Kowalevsky hypothesis that the primitive molars of ungulates were crested or lophodont. His method of research was an improvement of that introduced by Klever[1] upon the molars of the horse but his material included not only embryos of the horse, but

[1] "Zur Kenntniss der Morphogenese d. Equidengebisses," Morph. Jahrb. xv, p. 308, 1889.

of the pig as a modern bunodont, and as selenodont types a number of elk (*Alces palmatus*) embryos, one stage of the deer (*Capreolus caprœa*), abundant material of the ox and sheep as hypselenodont types, and of even greater interest, an embryo of one of the rare and transitional ancient group of Tragulidæ. As, in course of his investigation, he found abundant evidence in support of the remote tritubercular origin of these modern highly modified teeth, he adopts Cope's theory and Osborn's nomenclature and homologies, so that the reader can readily compare his plates and descriptions with the palæontological series as recently figured by Cope, Scott, Lydekker, Schlosser and others.

We may now quote his conclusions: "As a result of my investigations it is evident that both the bunodont Suidæ, and selenodont ruminants present a closely similar initial bunodont stage; according to which the Cope–Osborn opinions are in general conformed by embryological data, although in many points, especially as regards the (more elevated position of the) protocone, ontogenesis is no longer parallel with phylogenesis.

2. The differentiation soon follows whereby the separate cones and conids in the pig transform into pyramids and in the ruminants into crescents.

3. The transformation of the cones affects the separate cones in succession, not beginning with the protocone but with the earlier developed paracone. [The author has unconsciously strengthened his proof here, for it is well known that in the fossil series, the external upper cusps, i. e., the paracone and metacone, assume the selenoid form earlier and more universally than the protocone.]

4. In the last two upper deciduous premolars (D^4 D^3) from an originally conic metacone is developed a tooth with two cones, by the addition of the paracone; then, in D^4 at least, appears the protocone and finally the hypocone. In D^3 the protocone is the last cusp added. [Here again the author demonstrates an approximate parallelism between the ontogenesis and phylogenesis; he is evidently not aware of the observation of Schlosser that the upper premolar cusps do not appear in the same order and are therefore not homologous with the molar cusps. The actual order of evolution of the premolar cusps was observed by Osborn[1] in *Hyracotherium* as follows: A cusp *analogous* with the paracone (really the protocone) first appears, then the outer cusp divides into two, paracone and metacone,

[1] MSS. of chapter upon the *Equidæ* for the "American Fossil Mammals."

or more commonly the protocone appears second, and the metacone third, then the protoconule appears, the hypocone, followed finally by the metaconule. Similarly the lower premolars do not repeat the ancestral lower molar history, the order is protoconid, hypoconid, metaconid, entoconid. "Scott[1] has worked this out in the Artiodactyla as follows: *4th. upper premolar*—paracone (protocone), protocone deuterocone), metacone (tritocone), hypocone (tetartocone). *4th. lower premolar*—protoconid, metaconid (deuteroconid), hypoconid, entoconid.] Turning again to Laeker's investigation we find that:

5. In the lower jaw the fourth milk molar the order is protoconid, ? paraconid, (anterior cusp) hypoconid, metaconid, entoconid. [The homology of the paraconid is somewhat uncertain.]

In considering the exceptions between ontogenesis and phylogenesis here noted, we must remember the extreme antiquity of some of these structures, dating back to the middle and lower Eocene, for upon the whole the parallelism is most striking.—HENRY F. OSBORN, American Museum of Natural History, New York, May 23rd, 1892.

[1] "Osteology of *Poëbrotherium*," Journ. of Morphology, June 1891, pp. 48–49.

EMBRYOLOGY.[1]

On the Significance of Spermatogenesis.[2]—Auerbach has recently shown that a characteristic of the ovum and of the sperm is the fact, that the nucleus of the former takes on a red color, while that of the latter takes a blue, when both are treated exactly in the same way; to use Auerbach's expression, the hereditary substance of the male is *cyanophilous*, while that of the female is *erythrophilous*. I have tried this method of differentiating the sexual cells in the following animals: Asterias, Loligo, Unio, Limax, Rana, Bufo, Necturus, Diemyctylus, Mouse, Rabbit, Dog, Cat, Tortoise, Fowl, and Man. I used three kinds of aniline colors, viz., Cyanine, for the blue staining, and Erothrosine and Chromotrop for the red. These anilines do not appear in the list of colors used by Auerbach, but they give the characteristic stains for the sperm and the ovum as described by him.

In all of the animals mentioned, the nuclear contents of the well developed spermatozoon is eminently cyanophilous, that is, it takes cyanine in preference to chromotrop or erythrosine, and the nuclear contents of the ovarian ovum, particularly the nucleolus, is erythrophilous, that is, it takes either erythrosine or chromotrop in preference to cyanine.

It is difficult, however, to tell how much of the contents of the nucleus of the ovarian ovum, before a portion of its chromosome has been removed in the formation of polar globules, is directly comparable with the nuclear contents of a single spermatozoon, and we are therefore in doubt as to how far a color contrast obtained in differential staining of the two sexual cells actually indicates the real nature of the chromosomes contributed by two parents to the body of an embryo. It seems important to bear this point in mind, for, in instituting comparisons between the nucleus of the spermatozoon and of the ovarian ovum, as representative elements of the maternal and the paternal organisms, one is left to infer that the protoplasmic contents of the two are in an analogous stage of development—an inference open to objection. If the germinal vesicle of the well-developed ovarian ovum is to be compared with any structure in the male organism, it ought to be compared with the nucleus of the sperm mother cell or the spermatocyte, and not with that of the spermatozoon.

[1]This department is edited by Dr. E. A. Andrews, Johns Hopkins University.

[2]An abstract of a paper read before the Biological Club, Clark University, Worcester, Mass., March 10, 1892.

As I have already indicated in my previous note on the *Sertoli's cell*,[1] the cyanophilous quality of the spermatozoon nucleus is only the final phase of the varied series of color-reactions, which the sperm-producing cell presents at different stages of its development. The male germinal substance is not always blue in its color reaction. The male germinal substance at the beginning (spermatogonium stage), is not cyanophilous, but its color reaction is violet, due probably to a mixture of blue and red color; while at the next stage (spermatocyte), the color reaction of the chromosome is decidedly *green*, with one or two intensely erythrophilous nucleoli.

The transition of the chromatophilous qualities of the nuclear substance of the male cell from *violet* (spermatogonium), *green* (spermatocyte), *greenish-blue* (spermatide) and *deep blue* (spermatozoon), each new color-reaction corresponding to the morphological change in the sperm-cell, is certainly very instructive as clearly shown in my preparations illustrating mammalian spermatogenesis. The change in the chromatophilous quality of the male cell at different stages of its existence, may be due to corresponding changes in the quality of the protoplasm itself, and the whole phenomena of the successive series of forms of the sperm-cell must be due to the corresponding alteration in the nature of the protoplasmic material: when the male cell assumes its final stage as a well-developed spermatozoon, with its complicated apparatus for locomotion, accompanied, as in many cases, with an accessory apparatus, which facilitates the penetration of the sperm-nucleus into the substance of the ovum (as the head-spine for boring and the recurved hook at its tip, etc.), the quality of the protoplasmic substance has changed so much as to take an entirely different color from that of the ovum, which maintains the typical characteristics of an animal cell. That the ovum and the sperm become differently colored is, then, just what we might expect on *a priori* grounds, knowing the analogous differences mentioned in the history of the spermatozoon alone.

The critical point one is most interested to know is, whether the blue color, which characterized the nucleus of the spermatozoon, still persists or not, after the sperm-cell has entered into the substance of the ovum, and the form of its nucleus has undergone change by becoming spherical again. According to Auerbach's theory of heredity, the blue color must persist. I am not able to say anything definitely on this point, for I have not yet finished my research on this particular subject. I have said enough, however, to show, that the

[1] This Journal for May, 1892, p. 442.

cyanophilous quality of the paternal nucleus is by no means a constant character. It does not appear improbable that, after the sperm-nucleus had become transformed into the male pronucleus, indistinguishable from the female pronucleus in its contour, in its size, in the arrangement and the number of its chromosomes—the points strongly emphasized already by many workers in this field—the quality of the "male" and the "female" substance may no longer be more distinguishable in color reactions than they are in other respects; and that such differences as exist between them may be simply those that differentiate one organism from another of the same species.

We may say then, that the differentiations of the germ cells in the two sexes, which are shown not only in their form and size, but also in their chemical qualities, indicated by differential staining, are the device indicated (to use figurative language) to secure the union of two different individuals, with a special view to effect the transit of the male cell to the ovum and that with the successful union, or the close approximation, of two germ pronuclei, the "sexes" of the pronuclei become lost and they become non-sexual.

Just what determines the sex of the resulting embryo, which starts from this non-sexual stage, is quite another question.

Since, in general, it is the male that deviates most from the original or non-sexual form, the formation of the sperm-cell by a process much more complicated than that of the ovum may find a parallel among the similar facts in the evolution of the so-called "secondary sexual characters." The "primary" sexual structure—the germ-cell—may be said to undergo a series of changes parallel to those that take place in somatic structures. The significance of the complicated process of spermatogenesis when compared with oogenesis lies in the fact that it is part of a general law.

But if the "primary sexual character," a structure taking a direct part in reproduction, pursues in its development a path similar to that of the development of a "secondary sexual character," or structure taking only an indirect part in reproduction, it follows that the distinction between "primary" and "secondary" sexual character is more or less a nominal one.—S. WATASE, Clark University, Worcester, Mass.

Non-Sexual Reproduction in Sponges.[1]—Prof. H. V. Wilson of Chapel Hill, N. C., makes an interesting contribution to the subject of sexual and non-sexual reproduction of animals in a paper upon the

development of certain undescribed silicious sponges, found upon the Massachusetts Coast and in the Bahama Islands.

Though the egg development was studied in a number of sponges it is only the non-sexual development by gemmules that is of special interest in this connection.

In *Esperella fibrexilis* n. sp. of Woods Holl, Mass., the first appearance of the gemmules was traced to certain plump cells in the mesoderm. Such cells collect into groups of varying size: in each group the central ones are rather closely packed while the outer ones arrange themselves in the form of a follicle. Such clusters are the gemmules. Though it is possible that some gemmules may be formed from single cells, most are aggregates of many separate cells and in all growth takes place not only by cell division inside the gemmule, but by the actual fusion of large and small gemmules; so that the ultimate mass is of complex multicellular origin.

When the gemmule is full grown it forms a spherical mass of closely packed cells with faintly marked boundaries and full of yolk. The entire mass now projects into a water-canal, suspended as it were by the stalk-like attachments of the follicle.

In this ripe gemmule a remarkable process of subdivision now takes place. The solid aggregate of cells breaks down into clusters of cells, which are separated by liquid. The division continues until all the cells of the gemmule became separated from one another. Then the outer ones rearrange themselves to form an outer layer covering a central mass of amœboid cells, all connected together by processes, though separated by liquid.

The outer layer becomes ciliated and rich in orange colored pigment. At one pole, however, this change does not take place and at the same pole the inner cells crowd together to form a dense mass in which spicules appear.

In this condition the larva breaks out of its follicle, leaves the sponge and swims about actively in the water.

The gemmule larva thus closely resembles an egg larva in having an outer layer of pigmented, ciliated cells (ectoblast) replaced at the *anterior* pole by a thin layer of cells not pigmented nor ciliated; while the mesenchymatous central mass is dense and has spicules only at this same anterior end.

The larva attaches itself by its anterior end, but obliquely, so as to lie upon its side. Even before this a change extended from the anterior pole over the rest of the larva, the ectoderm becomes gradually

[1]Journal of Morphology, V, 1891.

flat and single. The sponge grows out as a circular disk, later becoming irregular. It is covered by the flat ectodermal membrane and inside contains spicules all through the mesenchymatous substance of the body.

The various canals and cavities of the sponge arise here and there with no arrangement. Later they connect with one another and break through to the surface as oscula and pores. The ciliated chambers are formed in the midst of special clusters of bulky mesoderm cells that divide to make walls about the intercellular space thus bounded. The way in which these special cells form the ciliated chambers varies in different larvæ.

In discussing the remarkable gemmule development the author points out that, if it has any value as indicating the past history of sponges, it is evidence of the former existence of a solid ancestor as maintained by Metschnikoff. It is mainly, however, the resemblance of this non-sexual larva to the egg larva of other sponges that is to be emphasized. Pointing out the resemblance in the formation of "germ layers" and the peculiarites of the anterior pole and changes of the "ectoderm," Dr. Wilson then accentuates the comparison by applying certain views of Prof. Weismann. As any mesenchyme cell may, apparently, produce an ovum so any mesenchyme cell may unite with others to make a gemmule. The gemmule cell has, alone, but little histogenetic plasma, but an aggregate can form a larva. The gemmule cell is thus a germ-cell differing from the ovum in having its germ plasma not partly converted into ovogenetic plasma. Some such likeness between the egg cell and the gemmule cell is necessary to explain the observed resemblances between the egg larva and the gemmule larva.

ARCHAEOLOGY AND ETHNOLOGY.[1]

MAN AND THE MYLODON.

Their Possible Contemporaneous Existence in the Mississippi Valley.

In one of the alcoves of the Museum of the Academy of Natural Sciences, Philadelphia is to be seen a considerable number of fossil bones of extinct animals belonging to the pleistocene period. In color, texture and general outward appearance they have a remarkable sim-

[1]This department is edited by Dr. Thomas Wilson, of the Smithsonian Institution.

ilarity as though they had belonged together. They are well preserved, firm in texture, and of a dark chocolate-brown color which has been attributed to ferruginous infiltration. They consist of a nearly entire skeleton of *Megalonyx jeffersoni*, teeth of the *Megalonyx dissimilis* and the *Ereptodon priscus*, bones of the *Mylodon harlani*, bones and teeth of the *Mastodon americanus*, and teeth of *Equus major* and *Bison latifrons*. Along with them is the os innominatum of a human subject. The question affecting the antiquity of man is whether these subjects, the bones of which were found together, were, when alive, contemporaneous, and whether the evidence of age in one is evidence of age in the other. They were all presented to the Academy by Dr. Dickeson at the meeting in October, 1846; description thereof is to be found in the Proceedings of the Society for that year, vol. iii, p. 106. Dr. Dickeson reported at that time that they were discovered by him in a single deposit at the foot of the bluff in the vicinity of Natchez, Mississippi. He says "The stratum that contained these organic remains is a tenacious blue clay that underlies the diluvial drift east of Natchez, and which diluvial deposit abounds in bones and teeth of the *Mastodon giganteum;* that they could not have drifted into the position in which they were found is manifest from several facts, first, that the plateau of blue clay is not appreciably acted on by those causes that produce ravines in the superincumbent diluvium; second, that the human bone was found at least two feet below the three associated skeletons of the *Megalonyx*, all of which, judging from the position or proximity of their several parts, had been quietly deposited in this locality independent of any active current or any other displacing powers; and lastly, because there is no mixture of diluvial drift with the blue clay, which latter retains its homogenous character equally in the higher parts which furnished the extinct quadrupeds and in its lower part which contained the remains of man." These specimens thus found associated were made the subject of investigation by Sir Charles Lyell, and afterwards by Dr. Joseph Leidy, the latter having published a memoir with illustrations of the human bone in the Transactions of the Wagner Free Institute of Science, vol. ii, p. 9. He says "It differs in no respect from an ordinary average specimen of the corresponding recent bone of man."

Dr. Leidy says Lyell expressed the opinion that, although the human bones may have been contemporaneous with those of the extinct animals with which it has been found, he thought it more probable that it had fallen from one of the Indian graves and had become mingled with the older fossils which were dislodged from the deeper part of

the cliff, and Dr. Leidy adds: "In the wear of the cliff the upper portion, with the Indian graves and human bones, would be likely to fall first, and the deeper portions with the older fossils, subsequently on the latter."

Although Dr. Leidy testifies to the general similarity of appearance of the human with the other bones, it does not seem to have occurred to him to have them analyzed and compared. Remembering the story told by the analysis and consequent comparison of the Caleveras skull with that of the rhinoceros skull found in a formation corresponding in age, though in a different locality; and of the fact apparent therefrom that the Caleveras skull was in an equally advanced stage of fossilization as the rhinoceros skull, I deemed it wise to make an examination and test by analysis. To this end I applied to Prof. Angelo Heilprin, and through him to the authorities of the Philadelphia Academy, so a few months since specimens certified by Prof. Heilprin have been taken, one from the bone of the man and the other from one of the bones of the mylodon, choosing those which for size, texture and general appearance bore the greatest likeness one to the other. These were submitted by me to Prof. F. W. Clarke, Chemist of the United States Geological Survey, on duty at the National Museum, who has just returned the result of his analysis, which is here published for the first time.

TWO FOSSIL BONES.

	Man. Per cent.	*Mylodon.* Per cent.
Loss at 100°C	4.55	6.77
Loss on ignition	16.54	21.18
Silica ($Si\ O_2$)	22.59	3.71
Phosphoric acid ($P_2\ O_5$)	17.39	23.24
Alumina ($Al_2\ O_3$)	3.21	4.02
Iron protoxide (Fe O)	5.65	4.44
Maganese protoxide (Mn O)	1.65	3.40
Lime (Ca O)	25.88	30.48
Magnesia (Mg O)	0.95	0.78
	98.41	97.02

Alkalies, carbonic acid and fluorine were not looked for, owing to the small amount of available material, hence the low summation.

The importance of this analysis will be apparent at a glance. The human bone is in a higher state of fossilization than is that of the

Mylodon. It has less lime and more silica. In their other chemical constituents they are without any great difference. Of lime the bone of the Mylodon has 30.48%, while that of man has but 25.88%. Of silica the Mylodon has 3.71%, while man has 22.59%. I am well aware of the ordinary uncertainty of this test when applied to specimens from different localities and subjected to different conditions; but in the present case no such differences exist. The bones were all encased in the same stratum of blue clay, and were subjected practically to the same conditions and surroundings. As one swallow does not make a summer so the discovery of one specimen does not prove the antiquity of man; but it is to be remarked that upon each discovery and in almost every investigation the evidence found points towards higher antiquity of man and tends to show the occupation of the earth by prehistoric man to be more and more extensive. This discovery is simply a fact to be put down to the credit of the high antiquity of man. We should proceed in the same direction to discover other evidences, to investigate the value of those already found; and as they accumulate, each one or all together should be given their fair value, in the endeavor to arrive at a truthful conclusion independent of *a priori* theory or preconceived idea.

MICROSCOPY.[1]

Methods of Decalcification. Continued.—*V. von Ebener's Hydrochloric Acid and Sodium Chloride Method.*[2]—To avoid the swelling caused by hydrochloric acid the author gives the following formula:

Hydrochloric acid	2.5	parts.
Alcohol	500.	"
Sodium chloride	2.5	"
Distilled water	100.	"

The fixed and hardened tissue is placed in this solution, which is daily strengthened by the addition of a small quantity of acid; when decalcified the preparations are washed in a half saturated aqueous solution of sodium chloride; when the solution shows an acid reaction it is neutralized by the addition of ammonia; this is repeated until the acid is entirely removed.

[1]Edited by C. O. Whitman, Clark University, Worcester, Mass.

[2]Wien. Sitzungsber., 1875, Zeit. f. wiss. Mikros., Bd. viii, p. 6, 1891.

Waldeyer's Hydrochloric Acid and Palladium Chloride Method.[1]—Small pieces of fixed and hardened tissue are decalcified in a solution consisting of:

Hydrochloric acid	10. parts.
Palladium chloride	1. "
Distilled water	1000. "

If not softened at the end of 24 hours the solution should be renewed; when decalcified the objects are washed in 70% alcohol until the acid is removed.

Bone Cells.—*Chiarugi's Method.*[2]—Small pieces of fresh bone are decalcified in picro-nitric acid prepared by adding 2 c.c. nitric acid to 100 c.c. saturated aqueous solution of picric acid; this solution is then diluted with two volumes of distilled water; when decalcified the tissue is washed in alcohol of increasing strengths. The sections are stained for a few minutes in a 1% eosine solution and decolorized in a 3% solution of potassium hydrate. The ground substance becomes colorless, while the bone cells and their processes are deeply stained. To fix the eosine the sections are washed and mounted in a 1% alum solution.

Fibres of Sharpey.—*Kölliker's Method.*[3]—The decalcified tissue is treated with concentrated acetic acid until transparent, when it is transferred to a saturated solution of indigo-carmine for a minute and then washed in distilled water; mount in glycerine or Canada balsam. The fibres of Sharpey are red, the remaining bone substance blue. Lithium carmine and safranin also differentiate the fibres.

Another method[4] employed is to heat the section in a crucible. The calcified fibres are shown with remarkable clearness.

Bone Medulla.—*Bizzozero's Method.*[5]—The author, after trying many methods, finds the following most useful in studying the elements

[1]Arch. f. mikro. Anat., Bd. xi, 1875; Stricker's Manual of Histology, 1872, p. 1052.

[2]Bollet. della Soc. trai cult. della Scienza Med. Siena. fasc. viii, 1886; Zeit. f. wiss. Mikros., Bd. iv, p. 490, 1888.

[3]Zeit. f. wiss. Zool., Bd. xliv, p. 644, 1886.

[4]Zeit. f. wiss. Mikros., Bd. iv, p. 87, 1888.

[5]Atti della R. Acad. della scienze di Torino, vol. xxv, p. 156; Arch. f. mikro. Anat., Bd. xxxv, p. 424, 1890; Zeit. f. wiss. Mikros., Bd. vii, p. 513, 1890.

of the medulla. The fresh tissue obtained by splitting the bone is fixed in Flemming's fluid, or still better, in a saturated solution of mercuric chloride in a 1% salt solution. After 2–3 hours the object is transferred to a mixture of the 1% salt solution and 90% alcohol, where it remains for 48 hours. It is then hardened in alcohol. The best results were obtained by staining the sections in hæmatoxylin or an aqueous solution of safranin and decolorizing with picric acid-alcohol. The amount of picric acid added to the alcohol is a matter of experiment. The proportions must be such that the protoplasm of the leucocytes remains uncolored when the nuclei of the red blood corpuscles are yellow. Müller's fluid fixes the red blood corpuscles better than sublimate. The sections are stained for a minute in a few c.c.'s of water to which have been added several drops of Ehrlich-Biondi's solution, then passed through the grades of alcohol, cleared in clove oil and mounted. The eosinophilous granules of the leucocytes are red or rose; the erythroblasts and blood corpuscles dark orange-red.

Löwit's Method.[1]—In the study of leucoblasts and erythroblasts Löwit employs the following method: Small pieces of bone medulla are fixed in a 1%–2% solution of platinum chloride in which they remain from 12–48 hours, then washed in running water for 24 hours, run through the grades of alcohol and imbedded in paraffine. The sections are stained for 2–4 minutes in an alcoholic solution of safranin, thoroughly washed in alcohol and treated with iodine-picric acid, which is prepared as follows: To a watch glass of 1% alcoholic solution of picric acid a drop or two of officinal iodine tincture is added. The sections remain in this solution for 10–30 seconds, when they are washed in alcohol, cleared in clove oil and mounted. Connective tissue and leucoblasts are yellow, erythroblasts red. If the sections are left too long in the iodine-picric acid or the solution is too strong all the elements appear a brownish-red. A little experience will soon enable one to obtain the desired results.

Demarbaix's Method.[2]—In studying the division and degeneration of the giant cells of the marrow employs the following method: The tissue is fixed for 24 hours in a mixture of

1% Chromic acid	14 parts.
Glacial acetic acid	1 part.
Distilled water	18 parts.

[1] Arch. f. mikro. Anat., Bd. xxxviii, p. 533, 1891.

[2] La Cellule T. v, p. 27, 1889; Zeit. f. wiss. Mikros., Bd. vii, p. 73. 1890.

It is then washed for 24 hours in water, passed through the grades of alcohol and imbedded in paraffine. The sections are stained with safranin according to the method of Babes,[1] viz.: To a 2% aqueous solution of aniline oil is added an excess of safranin. Stain in a thermostat at 50° C., decolorize for an instant in acid alcohol, mount in balsam.

SCIENTIFIC NEWS.

Recent Deaths.—Dr. Andrew Crombie Ramsay, the geologist, Dec. 9, 1891, at the age of 76 years. He was largely self-taught and was appointed Professor of Geology in University College, London, in 1848. In 1851 he was chosen to the same chair in the newly formed School of Mines. He was said to be without a superior as a lecturer. Dr. J. F. Williams, Professor of Mineralogy and Geology in Cornell University, was but 29 years old at the time of his death. He was a graduate of the Renssalaer Polytechnic Institute and received his doctor's degree from the University of Göttingen. Before going to Cornell he was connected with the Pratt Institute, at Brooklyn, and with the Arkansas Geological Survey. Baron Achille de Zigno, the well-known geologist, in Padua, January 18, 1892. Carl Freiherr von Camerlander, Praktikant in the Museum of the Geological Reichsanstalt, in Vienna, Jan. 17, 1892. J. W. Ewald, geologist, in Berlin, in December, 1891, aged 81. George Haggar, some forty years ago a collector of Lepidoptera, at Ore, England, Jan. 10, 1892, aged 75. Francis Archer, conchologist and entomologist, at Liverpool, March 1, 1892, aged 52.

Tufts College, at College Hill, Mass., has established a chair of biology, and Dr. J. S. Kingsley has been appointed to fill the position. Prof. J. P. Marshall retains the geology and mineralogy.

In a recent popular work on evolution is a "glossary" of scientific terms in which the following typographical error occurs: "Zoea, the larva of decayed (? decapod) crustaceans."

[1] Zeit. f. wiss. Mikro., iv, p. 470, 1887.